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USER'S GUIDE TO SHYDRO - VERSION 3.2

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Le programme SHYDRO-VERSION 3.2 est un modèle permettant d'établir les coûts des microprojets et des petits projets hydro-électriques. Il se fonde en grande partie sur un ensemble d'équations paramétriques pour l'établissement des coûts. Il a d'abord été élaboré par Monenco Limited, pour implantation sur le gros ordinateur DEC 20 (1984) puis il a été adapté pour les IBM-PC et compatibles et vendu sous le nom de SHYDRO.

Le programme SHYDRO-VERSION 3.2 est essentiellement une mise à jour de SHYDRO-VERSION 3.1. Cette mise à jour reteint les concepts originaux de SHYDRO mais intègre une série de fonctions conçues afin de rehausser la polyvalence de ce programme. Le modèle contenu dans la VERSION 3.1 de mise à jour a été agrandi pour y intégrer un canal usinier comprenant un déversoir et une structure de régulation par l'amont. Dans la VERSION 3.2 de mise à jour, une autre feuille de données de sortie a été incluse pour établir les dimensions de la turbine et de la génératrice. De cette façon, l'utilisateur pourra visualiser les dimensions et la configuration générale du matériel requis.

La version 3.2 de SHYDRO est conçue afin de tirer pleinement profit des capacités d'adressage par écran de la série des IBM-PC et des compatibles. En outre, SHYDRO-VERSION 3.2 est un programme à base de menus comportant l'introduction des réponses au moyen des touches de fonction du clavier. Le programme a été conçu afin de signaler tout problème associé au matériel (p. ex., l'imprimante n'est pas en fonction, etc.) ainsi que toute erreur dans l'introduction des données.

Les choix indiqués dans les menus ont été conçus afin de ne pas nécessiter d'explications, mais on peut accéder à des écrans d'aide au besoin.

La version 3.2 de SHYDRO a été rédigée en langage BASICA et elle a été mise à l'essai sur les versions 2.11 et 3.1 de DOS.

Le programme SHYDRO a été élaboré afin de calculer l'ordre de grandeur des coûts et les données relatives au matériel des microprojets et des petits projets hydro-électriques au moyen de données restreintes concernant l'emplacement, habituellement les renseignements qu'on peut obtenir aisément de cartes topographiques à l'échelle de 1/50 000.

Le modèle se fonde sur un plan conceptuel d'aménagement qui est typique d'un grand nombre de petits projets hydro-électriques. Ce plan conceptuel comporte les éléments suivants :

- barrage (en béton, en terre, en caissons de bois, à charpente de bois triangulé)
- déversoir
- passe à poissons

- structure de régulation
- canal usinier
- prise d'eau
- conduite forcée souterraine (en acier, en polyéthylène, en plastique renforcé de fibre de verre) ou extérieure (en acier et en polyéthylène)
- centrale
- poste et ligne de transport

PART ONE

INTRODUCTION

1.1 PREAMBLE

SHYDRO-VERSION 3.2 is a costing model for micro and small hydro developments. It is based largely on a set of parametric costing equations originally developed by Monenco Limited, for implementation of the DEC 20 mainframe (1984) and later adapted for IBM-PC and compatibles and marketed under the name SHYDRO.

SHYDRO-VERSION 3.2 is essentially an update of SHYDRO-VERSION 3.1. This update retains the original basis of SHYDRO but incorporates a series of features designed to enhance the versatility of that program. The model with the VERSION 3.1 update had been extended to incorporate a power canal with canal spillway and upstream control structure. Under the SHYDRO VERSION 3.2 update a further output data sheet has been included to size the turbine and generator unit. This will enable the user to visualize size and general configuration of equipment required.

SHYDRO-VERSION 3.2 is designed to take full advantage of screen addressing capabilities of the IBM PC line and compatibles. In addition, SHYDRO-VERSION 3.2 is a menu driven program with responses entered via the function keys on the keyboard. The program has been designed to check for problems related to the hardware (i.e. the printer is not turned on, etc.) and data input errors.

The menu choices have been designed to be self-explanatory, but an on-line package is present if necessary.

SHYDRO-VERSION 3.2 is written in BASICA and has been tested under DOS versions 2.11 and 3.1.

1.2 AUTHORIZATION

This update was carried out by ShawMont Newfoundland Limited, a subsidiary of Monenco Consultants Limited, under contract no. 23440-0-9579/01-SZ for the Department of Energy, Mines and Resources, Ottawa.

1.3 ACKNOWLEDGEMENTS

The project director for Energy, Mines and Resources was:

Mr. Tony Tung,
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Department of Energy, Mines and Resources,
Ottawa.

His interest and patience throughout this project are gratefully acknowledged. Responsibilities for this update work were shared by:

J. L. Gordon	-	formula development and study management.
R. M. Jost	-	formula development
H. J. Keats	-	programming.

The original version of SHYDRO was developed by R. Hutt, M. Orton and J. L. Gordon of Monenco.

PART TWO

DESIGN OF SHYDRO - VERSION 3.2

2.1 BACKGROUND

SHYDRO has been developed to calculate order of magnitude costs and equipment data of micro and small scale hydro developments on the basis of limited site data, typically, information that is readily obtainable from 1:50,000 topographic mapping.

The model is based on a conceptual development plan that is typical of many small hydroelectric developments. This development concept comprises the following elements:

- dam (concrete, earthfill, timber crib, timber "A" frame)
- spillway
- fishway
- control structure
- power canal
- intake
- penstock (buried steel, polyethylene, fibreglass reinforced plastic or surface steel and polyethylene)
- powerhouse
- substation and transmission line.

Data requirements for running the program are as follows:

- Site Data = 22 items
- Unit Cost Data = 7 items
- Economic Factors = 5 items

Costs and benefits are calculated using a set of parametric equations and printed out in a standard tabulation, showing direct, indirect costs, total project cost and benefit-cost analysis. The basic set of equations compute costs in 1986 Canadian dollars; however the results can be adjusted to any base year by choosing appropriate unit costs and adjustment factor values.

Equipment data provided by the program are calculated using a penstock formula developed by Fahlbusch (1982), and procedures and equations for powerhouse equipment sizing as developed by J.L. Gordon - Reference (5).

2.2 INPUT DATA

The site specific parameters required, are broken down into Site Data, Unit Cost Data and Economic Factors.

The twenty-two site specific parameters required are as follows:

SITE DATA	COMMENTS
1. Name of watershed (for future identification)	Name of watershed.
2. Site number (for future identification)	Name of site number.

2.2 INPUT DATA (Cont'd)

SITE DATA		COMMENTS
3.	Head (in metres)	Height between reservoir and tailwater obtained from best available mapping.
4.	Average flow (in cubic metres per second)	Determined from references (1, 2, 3 and 4).
5.	Penstock length (in metres)	Obtained from best available mapping.
6.	Access road length (in kilometres)	Obtained from best available mapping.
7.	Transmission line length (in kilometres)	Obtained from best available mapping.
8.	Dam height (to spillway crest in metres)	Maximum dam height to spillway crest.
9.	Dam length (abutment to abutment in metres)	Obtain from best available mapping.
10.	Canal length (in metres)	Obtain from best available mapping.
11.	Drawdown (full supply level to low supply level in metres)	Use if canal is required. Required for canal without control structure, enter zero for canal with control structure.
12.	Canal mean transverse slope (percent)	Use if canal is required.
13.	Canal depth of overburden (in metres)	Use if canal is required.
14.	Distance to town (in kilometres)	Obtain from best available mapping.
15.	Distance to concrete plant (in kilometres)	Obtain from best available mapping.
16.	Flood flow (in cubic metres per second)	Determined from references (1, 2, 3 and 4).
17.	Number of units	
18.	Plant design flow ratio (as a fraction of mean annual flow at the site)	Determined from references (1, 2, 3 and 4). [Typical value of 1.50].

2.2 INPUT DATA (Cont'd)

SITE DATA		COMMENTS
19.	Useable flow ratio (as a fraction of mean annual flow at the site)	Determined from references (1, 2, 3 and 4). [Typical value = 0.75].
20.	Fishway required (yes or no)	User determines if required. Enter 1.00 if required. Enter 0.00 if not required.
21.	Tailwater Elevation (in meters)	Obtain from best available mapping.
22.	Turbine Submergence (in meters)	User determines from references in Appendix I, Section 13. [Typically between ± 3 m].

UNIT COST DATA

The program also requires input of unit prices for calculation of the cost of some items. Most of these items are calculated using equations having an exponential form, as follows:

Cost $= KV^x$

where K is an input constant
V is the quantity of work
x is an exponential with a value less than unity

The unit cost parameter data includes cost of labour and material and are as follows:

UNIT COSTS		COMMENTS
1.	Timber crib ($/cubic metre)	Unit price based on quantity of 800 cubic metres.
2.	Concrete dam ($/cubic metre)	Unit price for mass concrete based on quantity of 1000m^3.
3.	Spillway concrete ($/cubic metre)	Unit price for structural concrete, including formwork and reinforcing.
4.	Earth excavation ($/cubic metre)	Based on quantity of 5000 m^3.
5.	Rock excavation	Based on quantity of 500 m^3.
6.	Access Road ($/kilometre)	Based on length of 5 km.
7.	Fishway ($/metre of dam height)	

2.2 INPUT DATA (Cont'd)

ECONOMIC FACTORS

The five economic factors required are as follows:

PARAMETERS	COMMENT
1. Equipment cost adjustment factor.	Cost escalation since 1986 as a fraction.
2. Fuel factor.	Factor = cost of diesel / cost of bunker "C" both expressed in mills/kWh.
3. Interest rate (%)	
4. O & M Cost (% of capital cost per annum)	Expressed as percentage of capital cost.
5. Revenue or value of power (mills/kilowatt hour)	

TYPICAL VALUES:

The typical values (in 1986 Canadian dollars) for site cost parameters are as follows:

TIMBER CRIB ($/cubic metre)	300.00
CONCRETE DAM ($/cubic metre)	400.00
SPILLWAY CONCRETE ($/cubic metre)	500.00
EARTH EXCAVATION	10.00
ROCK EXCAVATION	30.00
ACCESS ROAD ($/km)	50,000.00
FISHWAY ($/m of dam ht.)	41,000.00
EQUIPMENT COST ADJUSTMENT RATIO	1.00
FUEL FACTOR	2.50 (at remote sites supplied by diesel by diesel generation)
	1.00 (at sites interconnected to provincial grid)
INTEREST RATE (%)	10.00
O & M COST (% OF CAPITAL COST PER ANNUM)	1.50
REVENUE ($/MWH)	100.00 (equivalent to 100 mills/kWh)
USEABLE FLOW RATIO	0.75
DESIGN FLOW RATIO	1.50
FISHWAY REQUIRED (Y/N)	1.00 (indicating yes)

2.3 SHYDRO - OUTPUT

A sample output from Tutorial exercises #1 (see Section 4) is as follows:

(a) Calculated Data

Three data items are calculated by the computer. They are:

- Installed capacity
- Penstock diameter
- Capacity factor.

Installed capacity is calculated from plant design flow, plant head and a "water-to-wire" efficiency of 83%.

Within the program there is a routine for calculation of the optimum penstock diameter and plate thickness where applicable using a formula developed by Fahlbusch (1982), based on the plant design flow and developed head.

The capacity factor is calculated by dividing the usable turbine flow ratio by the plant design flow ratio. The capacity factor is used to calculate the energy generated for economic analysis purposes.

The following additional powerhouse equipment details are presented in the output data sheet to assist the user with powerhouse layout study and equipment cost inquiries:

- Turbine
  - number of runner blades
  - runner flow velocity
  - runner speed
  - flow per unit
  - throat diameter
  - runner submergence
- Generator
  - rotor speed
  - number of poles
  - rotor weight

(b) Information Statements

The output format is standardized with the exception of four information statements described below. These are included in the printout when applicable.

1. "NOTE-TRANSMISSION LINE LENGTH IN KILOMETRES EXCEEDS 10 X MW"

   This statements indicates to the program user that it may not be technically feasible to construct the transmission line for the estimated cost. The transmission voltage may be too low for the length of line required.

2. "NOTE-PENSTOCK LENGTH EXCEEDS 8 H (PRESSURE RELIEF VALVE ADDED)"

2.3 SHYDRO - OUTPUT (Cont'd)

(b) Information Statements (Cont'd)

3. "NOTE-PENSTOCK LENGTH EXCEEDS 20 X H" (SURGE TANK MAY BE REQUIRED)."

   This statement warns that the penstock input length is in excess of 20 times the rated head. Beyond this length, regulation of the unit becomes difficult and allowance should be made for a surge tank, which is not included in the program estimate.

4. "NOTE-SUBSTATION COST INCLUDED IN EQUIPMENT SUPPLY COST"

   This statement indicates that the cost of the substation is included with the powerhouse cost for sites with capacities over 5 MW.

(c) Calculated Costs

Least Cost Check

To indicate a first order of magnitude cost for the project, a least cost calculation is made and is included in the cost estimate print out. This "least cost" can be used as a rough check of the total project cost to determine if the site - specific input parameters are of the right order.

Note This cost is based on the power structure features only and is always in $ Can. 1986. See background description in Appendix I, Section 14.

The Program then calculates the costs of the following basic project components.

DAM

Calculates cost of three alternative dams, earthfill, concrete and timber crib; prints out the lowest cost alternative (dam plus spillway). If concrete or timber crib is selected, the spillway is incorporated in the dam. If earthfill is selected, program calculates cost of separate spillway. Dam cost is a function of dam length and height to spillway crest.

In addition, the type of dam selected by the program is listed under the dam heading in the Cost Estimate Summary. The alternate types of dam/spillway combinations which may be listed are as follows:

Dam	Spillway
"(EARTHFILL)"	$ COST
"(TIMBER)"	"SEE DAM"
"(CONCRETE)"	"SEE DAM"
"(A FRAME)"	"SEE DAM"

2.3 SHYDRO-OUTPUT (Cont'd)

(c) Calculated Costs (Cont'd)

SPILLWAY

Calculates cost as function of dam height and flood flow over a weir spillway within a rock abutment, with a spillway chute in cut.

UNWATERING

Calculates cost of unwatering dam site to build dam. Cost depends on type of dam and diversion flood flow. The diversion flow is estimated within the program to be 50 percent of the flood flow.

CONTROL STRUCTURE

Calculates cost as a function of plant flow capacity and reservoir drawdown.

CANAL

Calculates cost from earthwork quantities derived as a function of length, transverse slope depth of overburden and drawdown. For canals downstream of a control structure, drawdown is taken as nil and a canal spillway is added.

INTAKE

Calculates cost of a concrete intake structure, with an intake for each unit. Intake equipped with usual track-racks, gate, air vent. Cost is a function of number of units, and flow per unit.

PENSTOCK

Calculates cost of three alternative buried penstocks (polyethylene, fibreglass and steel) and two alternative surface penstock (polyethylene and steel), then selects type and cost of lowest cost alternative. Cost is a function of head, penstock length and number of units.

POWERHOUSE CIVIL WORKS

Calculates cost of powerhouse, with cost depending on number of units, installed capacity and rated head.

EQUIPMENT SUPPLY

Calculates overall cost of powerhouse equipment based on number of units, capacity and head.

EQUIPMENT ERECTION

Calculates cost to install all powerhouse equipment as a percentage of equipment cost.

2.3 SHYDRO - OUTPUT (Cont'd)

(c) Calculated Costs (Cont'd)

TRANSMISSION LINE AND SUBSTATION

Calculates cost as a function of total unit capacity and distance.

FISHWAY

Calculates cost of a function of dam height.

ACCESS ROAD

Calculates cost of access road as a function of length.

ADDITIONAL COSTS

Includes user supplied optional cost item and label in tabulation of direct costs.

SUBTOTAL DIRECT COSTS

CONTRACTOR'S OVERHEAD

Calculates cost of overhead as a function of civil works cost, distance to town and distance to concrete plant. This item is to allow sufficient monies in the estimate for the contractor to establish a site camp or set up a concrete plant, if distances to alternatives are excessive.

OWNER AND ENGINEERING

An allowance for the design, construction supervision and management costs. Calculated as a function of project cost.

INTEREST DURING CONSTRUCTION

Cost based on a function of project cost, length of construction, and interest rate.

The SHYDRO program totals the above costs and calculates the following:

TOTAL PROJECT COST

The Program has been tested against projects greater than 250 kW and has been found to estimate the project cost within 10 percent of the constructed plant cost. However, due to the unreliability of input data, the computed costs can only be regarded as having an accuracy in the region of 25 to 50 percent.

ANNUAL COST

Benefit calculated on basis of amortized cost at given interest rate and estimated operating and maintenance costs.

2.3 SHYDRO - OUTPUT (Cont'd)

(c) Calculated Costs (Cont'd)

ANNUAL BENEFIT

Benefit calculated on basis of installed capacity, capacity factor, and value of generated power.

BENEFIT/COST RATIO

Finally, the program calculates a simple benefit/cost ratio based on the above values.

A site with a benefit/cost ratio in excess of 0.75 may be worthy of more detailed evaluation.

(d) Equipment Data

The program calculates major equipment parameters, presented on the equipment data sheet, for use by the user in further study and equipment cost inquiries.

PENSTOCK

Penstock diameter and plate thickness, where applicable, are calculated from flow and developed head.

TURBINE

Turbine characteristics such as throat velocity, throat diameter and runner speed are calculated from a combination of primary input factors such as head, tailwater elevation and flow, and values selected using guidelines outlined in Appendix I, Section 13 for determination of draft tube factor, number of runner blades, and turbine submergence. Other parameters used in the calculation, i.e. turbine rated flow, turbine output capacity and plant capacity factor, are calculated by the program from the input data. A final selection of turbine speed is made where necessary to suit the synchronous speed selected for the generator.

GENERATOR

Generator data such as generator speed, number of poles and rotor weight are calculated based on the required system frequency and appropriate synchronous speed and generator pole configuration selected using guidelines outlined in Appendix I, Section 13.

PART THREE

RUNNING SHYDRO

3.0 RUNNING SHYDRO

Although SHYDRO is written to be self contained, it is assumed that the user can boot his IBM or compatible personal computer with a DOS (2.11 or later) operating system.

Once the IBM PC has been booted, proceed as follows:

1) If you own an IBM PC with two floppy disk drives place the SHYDRO diskette into Drive A and type the following command:

   SHYDRO carriage return

or

2) If you own and IBM PC with a hard disk, create a sub-directory from the root directory and with the DOS copy command, copy all files from the floppy to that sub-directory. From the root directory access the newly created sub-directory.

   Once this has been completed, type in the following command:

   SHYDRO followed by a carriage return.

3) The main menu of SHYDRO appears as follows:

```
                    SHYDRO
              ( VER 3.2, March 1991 )

          SHAWMONT NEWFOUNDLAND LIMITED
                P.O. BOX 9600
            St. JOHN'S, NEWFOUNDLAND
                   A1A 3C1
            TELEPHONE (709) 754-0250

              ----- MAIN MENU -----

F1 Examine/Change input parameters     F6 Reset all input parameters to zero
F2 Initialize default cost parameters  F7 This key reserved (future updates)
F3 Send results to printer             F8 New user of SHYDRO
F4 Write/Retrieve data to/from disk    F9 RUN
F5 Exit program and return to DOS      F10 HELP <press key marked F10>

                  ENTER MENU SELECTION
```

3.0 RUNNING SHYDRO (Cont'd)

The ten function keys (also known as soft keys) are used to select the options:

For example: By pressing the key marked F8 a brief history of SHYDRO is presented on the terminal.

The Function Keys

The following section describes what each function key does at the main menu level.

Function Key F1

Pressing F1 clears the screen and displays the following menu:

```
                                SHYDRO
                        ( VER 3.2, March 1991 )

 ------------ Cost Data ------------ INPUT MENU ---------- Site Data -----------
  1) TIMBER CRIB WORK      ($/m^3)       0.00   19) GROSS HEAD              (m)    0.00
  2) DAM CONCRETE          ($/m^3)       0.00   20) DAM HEIGHT              (m)    0.00
  3) SPILLWAY CONCRETE     ($/m^3)       0.00   21) DAM LENGTH              (m)    0.00
  4) EARTH EXCAVATION      ($/m^3)       0.00   22) DRAWDOWN                (m)    0.00
  5) ROCK EXCAVATION       ($/m^3)       0.00   23) CANAL LENGTH            (m)    0.00
  6) ACCESS ROAD            ($/km)       0.00   24)    TRANSVERSE SLOPE             0.00
  7) FISHWAY      ($/m OF DAM HT)        0.00   25)    OVER BURDEN DEPTH    (m)     0.00
  8) INTEREST RATE             (%)       0.00   26) PENSTOCK LENGTH         (m)    0.00
  9) O & M COST     (% PER ANNUM)        0.00   27)    SURFACE =1 / BURIED =0       0.00
 10) REVENUE               ($/MWh)       0.00   28) AVERAGE FLOW         (m^3/s)   0.00
 11) EQUIP. ADJUSTMENT FACTOR            0.00   29) NUMBER OF UNITS                  0.00
 12) FUEL FACTOR                         0.00   30) TRANSMISSION LINE LENGTH        0.00
 13) FISHWAY          Y =1 / N =0        0.00   31) ACCESS ROAD LENGTH    (km)      0.00
 14) FLOOD FLOW            (m^3/s)       0.00   32) DISTANCE TO TOWN      (km)      0.00
 15) PLANT DESIGN FLOW RATIO             0.00   33) DIST. TO CONC. PLANT  (km)      0.00
 16) USEABLE FLOW RATIO                  0.00   34) CONTROL STRUCTURE Y=1/N=0       0.00
 17) TURBINE SUBMERGENCE                 0.00   35) TAILWATER ELEVATION             0.00
 18) ADDITIONAL COST x $1000             0.00   36) WATER SHED   (Name of)
                                                37) SITE NUMBER  (Name of)

PRESS <F10> FOR HELP
 ENTER COMMAND STRING ?
```

The parameters on the left are the regional cost values including labour and materials. The parameters located on the right are Site Specific and can be obtained from a large scale map of the site.

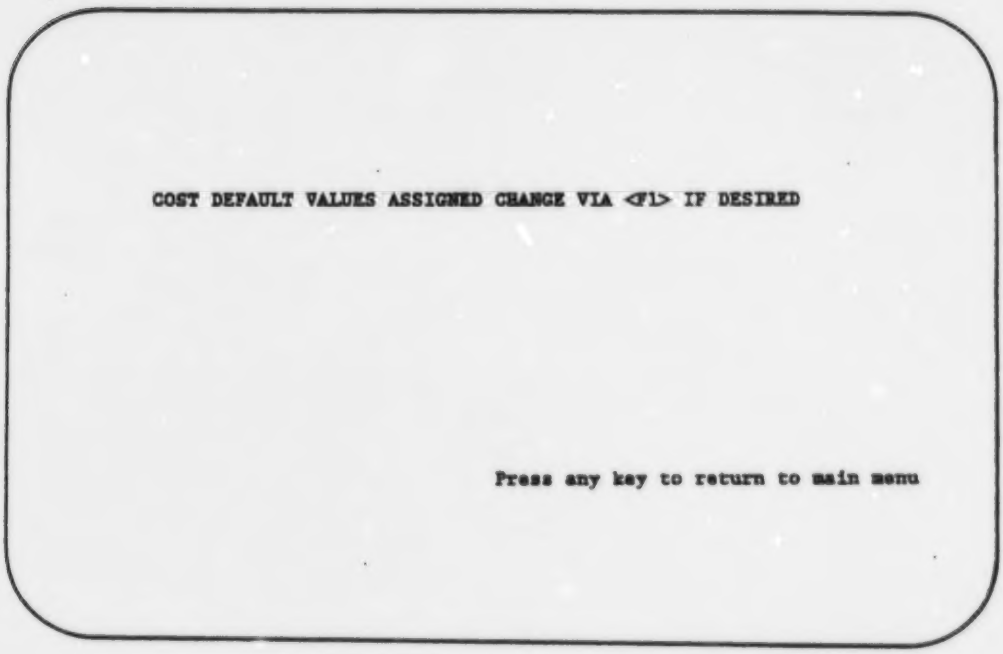
When choosing the Help key <F10> the following screen will be displayed:

```
                              HELP  SCREEN

 By entering a string of commands the displayed parameters can be
changed. The command language is as follows :

  1-5          :  changes the parameters 1 to 5 inclusive
  1,5,7        :  changes the parameters 1 then 5 then 7
  1-5,7,9-11   :  changes the parameters 1 to 5 followed by 7
                  and parameters 9 to 11
  S            :  changes all the Site parameters
  F            :  indicates you have Finished changing the parameters
                  and returns you to main menu
  R            :  Runs the program on the displayed data parameters
  D            :  re-displays input menu if an error has occured
  Q            :  Exit from SHYDRO-PC and return to DOS



                                        Press any key to return to menu
```

The user, via the above commands, can change any or all of the parameters to perform a sensitivity analysis, etc.

Function Key F2

Pressing F2 causes SHYDRO to set the cost parameters to their default values. The screen is cleared and the following message is displayed to indicate the default values have been changed:



The default values are as follows:

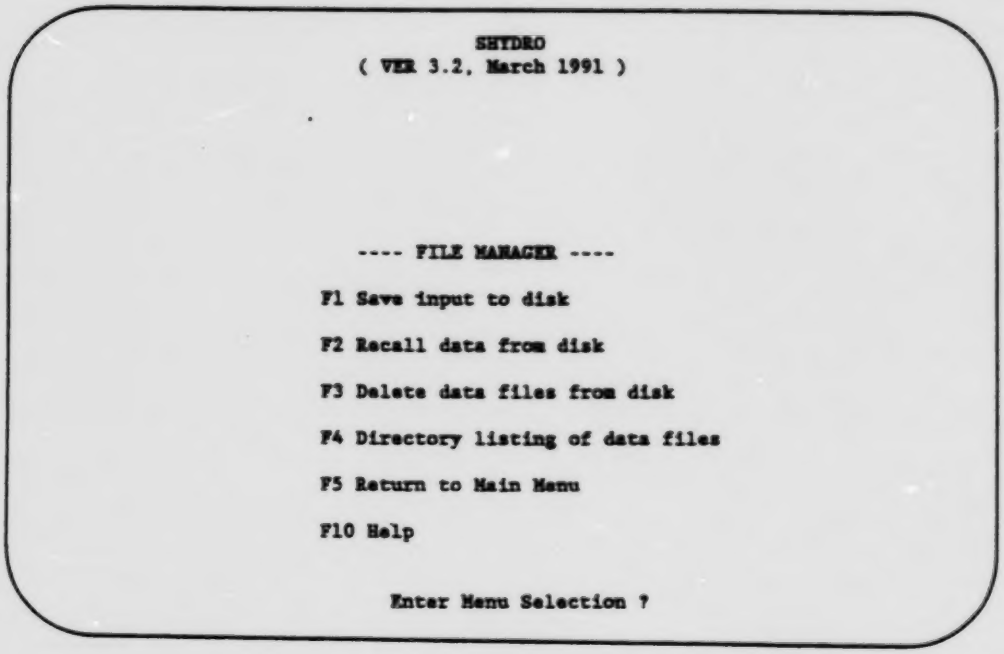
```
                                SHYDRO
                          ( VER 3.2, March 1991 )

 ------------ Cost Data ------------ INPUT MENU ---------- Site Data -----------
  1) TIMBER CRIB WORK      ($/m^3)     300.00   19) GROSS HEAD              (m)   0.00
  2) DAM CONCRETE          ($/m^3)     400.00   20) DAM HEIGHT              (m)   0.00
  3) SPILLWAY CONCRETE     ($/m^3)     500.00   21) DAM LENGTH              (m)   0.00
  4) EARTH EXCAVATION      ($/m^3)      10.00   22) DRAWDOWN                (m)   0.00
  5) ROCK EXCAVATION       ($/m^3)      20.00   23) CANAL LENGTH            (m)   0.00
  6) ACCESS ROAD             ($/km)  60000.00   24)    TRANSVERSE SLOPE           0.00
  7) FISHWAY      ($/m OF DAM HT)     41000.00   25)    OVER BURDEN DEPTH    (m)   0.00
  8) INTEREST RATE               (%)     10.00   26) PENSTOCK LENGTH         (m)   0.00
  9) O & M COST     (% PER ANNUM)         1.50   27)    SURFACE =1 / BURIED =0     0.00
 10) REVENUE                ($/MWh)     100.00   28) AVERAGE FLOW        (m^3/s)   0.00
 11) EQUIP. ADJUSTMENT FACTOR              1.00   29) NUMBER OF UNITS                0.00
 12) FUEL FACTOR                           1.00   30) TRANSMISSION LINE LENGTH       0.00
 13) FISHWAY          Y =1 / N =0          0.00   31) ACCESS ROAD LENGTH     (km)    0.00
 14) FLOOD FLOW             (m^3/s)        0.00   32) DISTANCE TO TOWN       (km)    0.00
 15) PLANT DESIGN FLOW RATIO               0.00   33) DIST. TO CONC. PLANT   (km)    0.00
 16) USEABLE FLOW RATIO                    0.00   34) CONTROL STRUCTURE Y=1/N=0      0.00
 17) TURBINE SUBMERGENCE                   0.00   35) TAILWATER ELEVATION            0.00
 18) ADDITIONAL COST x $1000               0.00   36) WATER SHED    (Name of)
                                                  37) SITE NUMBER   (Name of)

PRESS <F10> FOR HELP
 ENTER COMMAND STRING ?
```

Function Key F3

Pressing F3 causes the output to be sent to the printer.

Function Key F4

Pressing F4 places SHYDRO in a diskette read/write mode. The following menu is displayed:


SHYDRO
(VER 3.2, March 1991)
---- FILE MANAGER ----
F1 Save input to disk
F2 Recall data from disk
F3 Delete data files from disk
F4 Directory listing of data files
F5 Return to Main Menu
F10 Help
Enter Menu Selection ?

Pressing F1	writes the input parameters (as displayed via the Main Menu by pressing F1) to the disk. The user must supply the name of the file to which data is to be written.*
Pressing F2	reads data from the diskette into SHYDRO. The user must supply the name of the file containing the data. If the user forgets the name of the data file at this point, pressing the carriage return causes the program to return to the "file manager menu".**
Pressing F3	prompts the user to supply a file name that will be deleted from the disk.
Pressing F4	displays a directory of all of the stored data files located on the diskette in Drive B.
Pressing F5	returns the user to the main menu.
Pressing F10	displays the help commands.

* File names must be eight characters or less in length and not contain extensions.

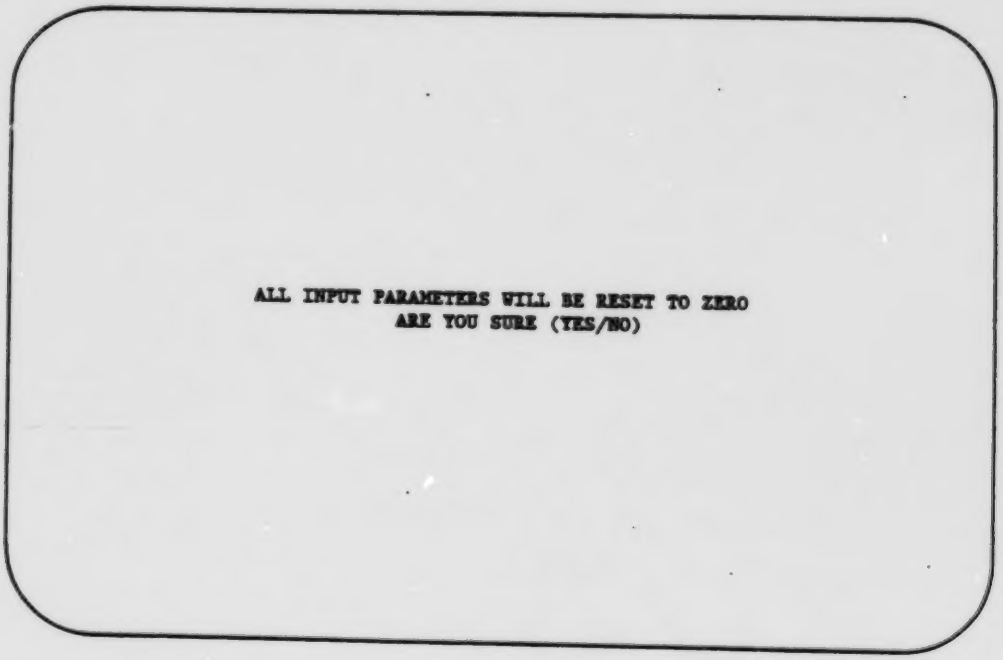
** The user should remember to save data to disk via the F4 key if desired, before exiting SHYDRO

Function Key F5

By pressing F5, the user causes SHYDRO to stop execution and revert command back to DOS. The screen is cleared and the user is asked to confirm with a "Y" or "N" whether F5 was meant to be pressed.

Function Key F6

Pressing F6 causes SHYDRO to reset ALL input parameters to zero. The user can then set the cost parameters to their defaults via the F2 key if desired. The screen clears and displays the following message:



The user is asked to confirm the message with a "Y" or "N".

Function Key F7

F7 is reserved for possible future modifications to shydro and does not have any effect on SHYDRO Version 3.2.

Function Key F8

Pressing F8 displays a message of introduction to SHYDRO.

Function Key F9

Pressing F9 runs the input data through the calculation code of SHYDRO. Results are displayed on the screen and can be routed to the printer via the F3 key at the main menu level upon completion of the run mode.

Function Key F10

Pressing F10 displays the on-line help package for the main menu level.

PART FOUR

TUTORIAL RUN OF SHYDRO

4.0 TUTORIAL RUN OF SHYDRO

Exercise 1

The following is a sample run of SHYDRO which should help the first time user gain experience with SHYDRO using the two drive system.

Begin the run by placing the SHYDRO diskette in Drive A:.

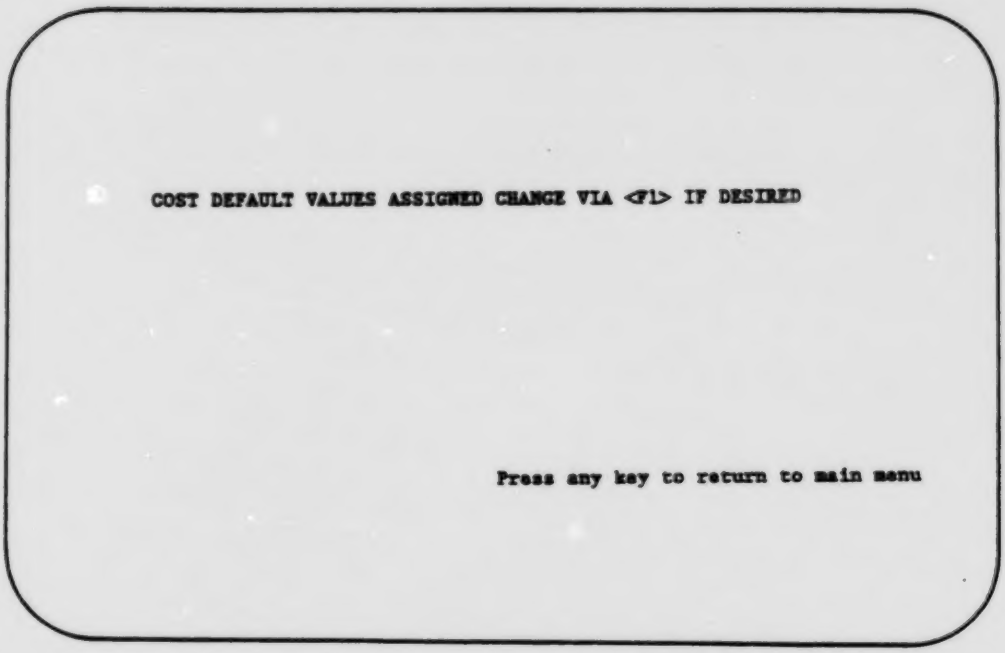
Type in the following command:

SHYDRO

After a few moments the main menu of SHYDRO is displayed as follows:

```
                              SHYDRO
                        ( VER 3.2, March 1991 )


                    SHAWMONT NEWFOUNDLAND LIMITED
                           P.O. BOX 9600
                      ST. JOHN'S, NEWFOUNDLAND
                             A1A 3C1
                      TELEPHONE (709) 754-0250


                          ----- MAIN MENU -----

  F1 Examine/Change input parameters      F6 Reset all input parameters to zero

  F2 Intialize default cost parameters    F7 This key reserved (future updates)

  F3 Send results to printer              F8 New user of SHYDRO

  F4 Write/Retrieve data to/from disk     F9 RUN

  F5 Exit program and return to DOS       F10 HELP <press key marked F10>


                          ENTER MENU SELECTION
```

Press the key marked F2. The following message is displayed.



Press any key on the keyboard (the space bar is always a good choice due to its large size). The main menu appears. Press the key marked F1. The following screen is displayed.

```
                                SHYDRO
                          ( VER 3.2, March 1991 )

---------- Cost Data ---------- INPUT MENU ---------- Site Data ----------
 1) TIMBER CRIB WORK     ($/m^3)    300.00   19) GROSS HEAD              (m)    0.00
 2) DAM CONCRETE         ($/m^3)    400.00   20) DAM HEIGHT              (m)    0.00
 3) SPILLWAY CONCRETE    ($/m^3)    500.00   21) DAM LENGTH              (m)    0.00
 4) EARTH EXCAVATION     ($/m^3)     10.00   22) DRAWDOWN                (m)    0.00
 5) ROCK EXCAVATION      ($/m^3)     20.00   23) CANAL LENGTH            (m)    0.00
 6) ACCESS ROAD           ($/km)  60000.00   24)    TRANSVERSE SLOPE             0.00
 7) FISHWAY      ($/m OF DAM HT)  41000.00   25)    OVER BURDEN DEPTH    (m)    0.00
 8) INTEREST RATE             (%)    10.00   26) PENSTOCK LENGTH         (m)    0.00
 9) O & M COST     (% PER ANNUM)     1.50   27)    SURFACE =1 / BURIED =0       0.00
10) REVENUE             ($/MWh)    100.00   28) AVERAGE FLOW        (m^3/s)    0.00
11) EQUIP. ADJUSTMENT FACTOR          1.00   29) NUMBER OF UNITS                0.00
12) FUEL FACTOR                       1.00   30) TRANSMISSION LINE LENGTH       0.00
13) FISHWAY          Y =1 / N =0      0.00   31) ACCESS ROAD LENGTH     (km)    0.00
14) FLOOD FLOW          (m^3/s)       0.00   32) DISTANCE TO TOWN       (km)    0.00
15) PLANT DESIGN FLOW RATIO           0.00   33) DIST. TO CONC. PLANT   (km)    0.00
16) USEABLE FLOW RATIO                0.00   34) CONTROL STRUCTURE Y=1/N=0       0.00
17) TURBINE SUBMERGENCE               0.00   35) TAILWATER ELEVATION             0.00
18) ADDITIONAL COST x $1000           0.00   36) WATER SHED    (Name of)
                                             37) SITE NUMBER   (Name of)

PRESS <F10> FOR HELP
 ENTER COMMAND STRING ?
```

On the bottom line of the screen the "ENTER COMMAND?" prompt is displayed. Type an "S" followed by a carriage return. The bottom line prompts you for the data to be entered. The first prompt is for the "Gross Head". Type in 40 followed by a carriage return. Note the entry in the table changes to 40.00. Continue to type in the correct values as follows according to the displayed prompt.

```
                                SHYDRO
                          ( VER 3.2, March 1991 )

---------- Cost Data ---------- INPUT MENU ---------- Site Data ----------
 1) TIMBER CRIB WORK     ($/m^3)    300.00   19) GROSS HEAD             (m)  38.47
 2) DAM CONCRETE         ($/m^3)    400.00   20) DAM HEIGHT             (m)   8.35
 3) SPILLWAY CONCRETE    ($/m^3)    500.00   21) DAM LENGTH             (m)  70.00
 4) EARTH EXCAVATION     ($/m^3)     10.00   22) DRAWDOWN               (m)   2.50
 5) ROCK EXCAVATION      ($/m^3)     20.00   23) CANAL LENGTH           (m)2250.00
 6) ACCESS ROAD            ($/km)  60000.00   24)    TRANSVERSE SLOPE          0.25
 7) FISHWAY      ($/m OF DAM HT)   41000.00   25)    OVER BURDEN DEPTH   (m)   0.50
 8) INTEREST RATE             (%)    10.00   26) PENSTOCK LENGTH        (m) 225.00
 9) O & M COST     (% PER ANNUM)      1.50   27)    SURFACE =1 / BURIED =0    0.00
10) REVENUE              ($/MWh)    100.00   28) AVERAGE FLOW       (m^3/s)   9.58
11) EQUIP. ADJUSTMENT FACTOR          1.00   29) NUMBER OF UNITS               1.00
12) FUEL FACTOR                       1.00   30) TRANSMISSION LINE LENGTH      0.50
13) FISHWAY         Y =1 / N =0       1.00   31) ACCESS ROAD LENGTH    (km)    0.75
14) FLOOD FLOW           (m^3/s)     80.00   32) DISTANCE TO TOWN      (km)    5.00
15) PLANT DESIGN FLOW RATIO           1.50   33) DIST. TO CONC. PLANT  (km)    5.00
16) USEABLE FLOW RATIO                0.84   34) CONTROL STRUCTURE Y=1/N=0     1.00
17) TURBINE SUBMERGENCE              -0.75   35) TAILWATER ELEVATION          30.00
18) ADDITIONAL COST x $1000         110.50   36) WATER SHED   Sample Problem
                                             37) SITE NUMBER  007

PRESS <F10> FOR HELP
 ENTER COMMAND STRING ?
```

Type in a "10" followed by a carriage return to change the revenue ($/MWH) to 50.

4.0 TUTORIAL RUN OF SHYDRO (Cont'd)

Type in an R, to run the data through SHYDRO, followed by a carriage return. The following screen is displayed:

```
SITE DATA
        INSTALLED CAPACITY                      4,500 kW
        NUMBER OF UNITS                             1
        GROSS HEAD                             38.47 m
        TAILWATER ELEVATION                    30.00 m
        TURBINE SUBMERGENCE                    -0.75 m
        AVERAGE FLOW                           9.580 m^3/s
        FLOOD FLOW                                80 m^3/s
        PLANT DESIGN FLOW RATIO                 1.50
        USEABLE FLOW RATIO                      0.84
        HEIGHT OF DAM                           8.35 m
        LENGTH OF DAM                          70.00 m
        DRAWDOWN (F.S.L. - L.S.L.)              2.50 m
        CANAL LENGTH                           2,250 m
        CANAL MEAN TRANSVERSE SLOPE             0.25
        CANAL DEPTH OF OVER BURDEN              0.50 m
        PENSTOCK LENGTH (BURIED)               225.00 m
        TRANSMISSION LINE LENGTH                0.50 km
        ACCESS ROAD LENGTH                      0.75 km
        DISTANCE TO TOWN                        5.00 km
        DISTANCE TO CONCRETE PLANT              5.00 km

                                        Press any key to continue
```

Press the spacebar to display the following screen:

```
                              UNIT COST DATA

      WATER SHED :          Sample Problem
      SITE NAME  :          007
      INSTALLED CAPACITY : 30,525 kW

UNIT COST DATA

                TIMBER CRIB WORK                      300.00 m^3
                DAM CONCRETE                          400.00 m^3
                SPILLWAY CONCRETE                     500.00 m^3
                EARTH EXCAVATION                       10.00 m^3
                ROCK EXCAVATION                        20.00 m^3
                ACCESS ROAD                        60,000.00 km
                FISHWAY                            41,000.00 m

ECONOMIC FACTORS

                EQUIPMENT COST ADJUSTMENT FACTOR       1.00
                FUEL FACTOR                            1.00
                INTEREST RATE                         10.00
                OPERATION AND MAINTENANCE              1.50
                REVENUE                               50.00 mills/KWh

                     Press any key to continue or B to display previous screen
```

Press the spacebar to get the following screen or a B to display the previous screen.

```
                              COST ESTIMATE

      WATER SHED :          Sample Problem
      SITE NAME  :          007
      INSTALLED CAPACITY :   4,500 kW

COST ESTIMATE

              DAM (CONCRETE)                                  $517,601
              UNWATERING                                       $60,000
              CONTROL STRUCTURE                               $152,922
              CANAL SLOPED (EARTH/ROCK)                       $581,951
              INTAKE                                          $254,594
              PENSTOCK (FIBERGLASS)                           $253,877
              POWERHOUSE  -  CIVIL                            $753,687
                          -  EQUIPMENT SUPPLY               $1,551,710
                          -  EQUIPMENT ERECTION               $465,513
              TRANSMISSION LINE AND SUBSTATION                $243,731
              FISHWAY                                         $342,350
              ACCESS ROAD                                      $59,670
              ADDITIONAL COST                                 $110,500


                    Press any key to continue or B to display previous screen
```

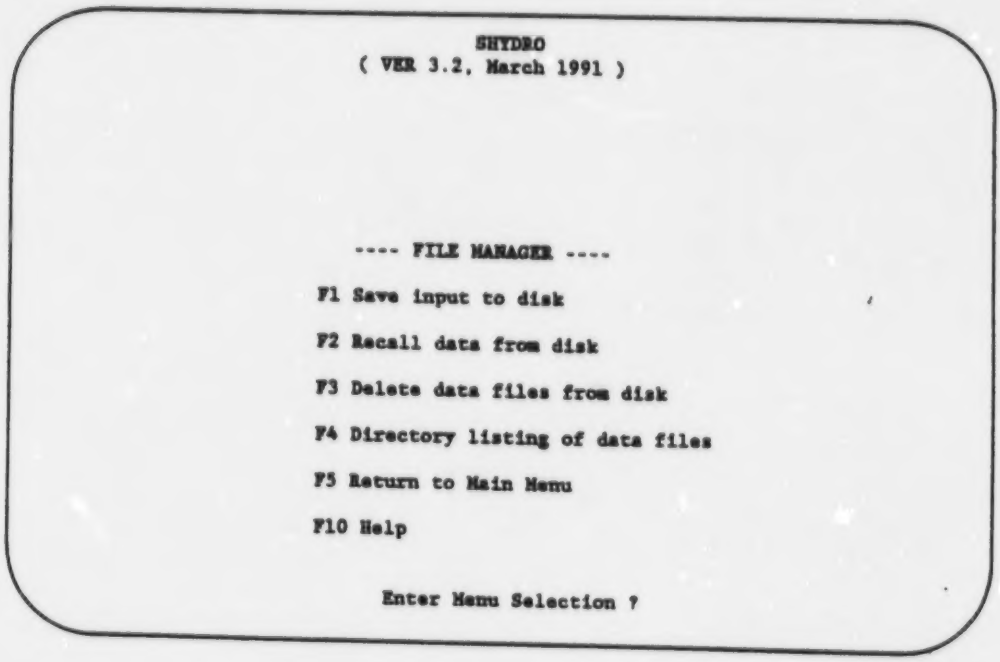
Press the spacebar to get the following screen or a B to display the previous screen.

```
                              SUMMARY SHEET

      WATER SHED :          Sample Problem
      SITE NAME  :          007
      INSTALLED CAPACITY :   4,500 kW

      LEAST COST ($C1986)                                  $11,608,100

COST SUMMARY

                        SUBTOTAL DIRECT COSTS               $5,348,080
                        CONTRACTOR OVERHEAD                    $86,120
                        OWNER AND ENGINEERING                 $610,050
                        INTEREST DURING CONSTRUCTION          $263,260
                        TOTAL PROJECT COST                  $6,307,510


BENEFIT/COST ANALYSIS

                        ANNUAL COST                           $725,360
                        ANNUAL BENEFIT                      $1,103,730
                        BENEFIT/COST RATIO                       1.522


                     Press any key to continue or B to display previous screen
```

Press the spacebar to return to main menu or a B to display the previous screen.

After making sure the printer is turned on, press the key marked F3 to get a hard copy of the results.

Press the key marked F4. The following "File Manager" menu is displayed.


SHYDRO
(VER 3.2, March 1991)
---- FILE MANAGER ----
F1 Save input to disk
F2 Recall data from disk
F3 Delete data files from disk
F4 Directory listing of data files
F5 Return to Main Menu
F10 Help
Enter Menu Selection ?

Press F1 to save the input data to disk. The prompt of the bottom line of the screen is asking for a file name. Type in "Sample" followed by a carriage return. The input data is now written to the diskette in Drive A: and the main menu is again displayed.

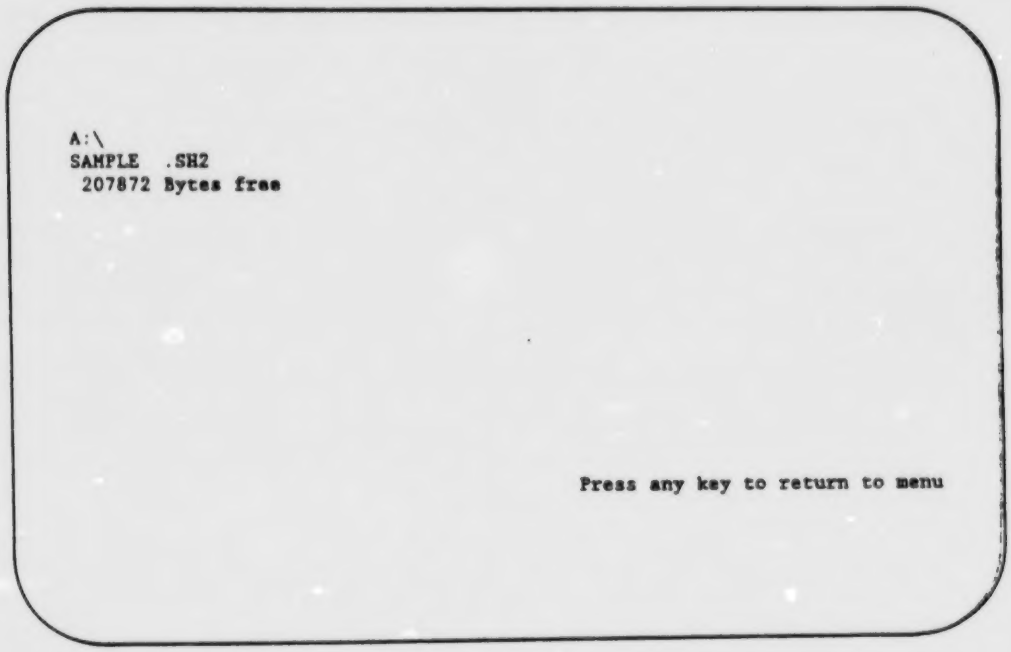
Press F5 followed by a "Y" to return to DOS, ending Exercise 1.

Exercise 2

To begin the program, again type in:

SHYDRO followed by a carriage return.

After the main menu is displayed press the key marked F4 to display the "File Manager" menu. Press the key marked F3. The following screen is then displayed.



Press the spacebar to return to the "File Manager" menu. Press the F2 key and type in "Sample" followed by a carriage return in response to the prompt displayed at the bottom of the screen. The data saved in the previous exercise is recalled from disk. Press the key marked F1 to examine the input data. Enter Q followed by a carriage return to exit the program and return to DOS. Confirm your request with a "Y".

PRINT-OUT OF SAMPLE SITE

SHYDRO-PC VERSION 3.2 MARCH 1991

DATA SHEET

DATE : 03-27-1991

WATER SHED : Sample Problem

SITE NAME : 007

FILE : Sample

SITE DATA

INSTALLED CAPACITY	4,500	kW
NUMBER OF UNITS	1	
GROSS HEAD	38.47	m
TAILWATER ELEVATION	30.00	m
TURBINE SUBMERGENCE	-0.75	m
AVERAGE FLOW	9.58	m^3/s
FLOOD FLOW	80	m^3/s
PLANT DESIGN FLOW RATIO	1.50	
USEABLE FLOW RATIO	0.84	
HEIGHT OF DAM	8.35	m
LENGTH OF DAM	70.00	m
DRAWDOWN (F.S.L. - L.S.L.)	2.50	m
CANAL LENGTH	2,250	m
CANAL MEAN TRANSVERSE SLOPE	0.25	
CANAL DEPTH OF OVER BURDEN	0.50	m
PENSTOCK LENGTH (BURIED)	225.00	m
TRANSMISSION LINE LENGTH	0.50	km
ACCESS ROAD LENGTH	0.75	km
DISTANCE TO TOWN	5.00	km
DISTANCE TO CONCRETE PLANT	5.00	km

UNIT COST DATA

TIMBER CRIB WORK	300.00	m^3
DAM CONCRETE	400.00	m^3
SPILLWAY CONCRETE	500.00	m^3
EARTH EXCAVATION	10.00	m^3
ROCK EXCAVATION	20.00	m^3
ACCESS ROAD	60,000.00	km
FISHWAY	41,000.00	m

ECONOMIC FACTORS

EQUIPMENT COST ADJUSTMENT FACTOR	1.00	
FUEL FACTOR	1.00	
INTEREST RATE	10.00	
OPERATION AND MAINTENANCE	1.50	
REVENUE	50.00	mills/KWh

SHYDRO-PC VERSION 3.2 MARCH 1991

COST ESTIMATE

DATE : 03-27-1991

WATER SHED : Sample Problem

SITE NAME : 007

FILE : Sample

INSTALLED CAPACITY : 4,500 kW

LEAST COST ($C1986) See Appendix I-Section .14 $11,608,100

COST ESTIMATE

DAM (CONCRETE)	$517,600
UNWATERING	$60,000
CONTROL STRUCTURE	$152,920
CANAL SLOPED (EARTH/ROCK)	$581,950
INTAKE	$254,590
PENSTOCK (FIBERGLASS)	$253,870
POWERHOUSE - CIVIL	$753,680
- EQUIPMENT SUPPLY	$1,551,710
- EQUIPMENT ERECTION	$465,510
TRANSMISSION LINE AND SUBSTATION	$243,730
FISHWAY	$342,350
ACCESS ROAD	$59,670
ADDITIONAL COST	$110,500
SUBTOTAL DIRECT COSTS	$5,348,080
CONTRACTOR OVERHEAD	$86,120
OWNER AND ENGINEERING	$610,050
INTEREST DURING CONSTRUCTION	$263,260
TOTAL PROJECT COST	$6,307,510

BENEFIT/COST ANALYSIS

ANNUAL COST	$725,360
ANNUAL BENEFIT	$1,103,730
BENEFIT/COST RATIO	1.522

SHYDRO-PC VERSION 3.2 MARCH 1991

EQUIPMENT DATA SHEET

DATE : 03-27-1991

WATER SHED : Sample Problem

SITE NAME : 007

FILE : Sample

INSTALLED CAPACITY : 4,500 kW

AVERAGE YEARLY ENERGY : 22.10 GWh

POWERHOUSE EQUIPMENT DATA

PENSTOCK (FIBERGLASS)		
Penstock Diameter	2.38	m
Penstock Thickness	10	mm
TURBINE (Horizontal Shaft)		
Number of Runner Blades per Unit	13	
Runner Throat Velocity	8.43	m/s
Runner Speed	360.0	rpm
Turbine Flow per Unit	14.43	m^3/s
Turbine Throat Diameter	1.48	m
Turbine Submergence	-0.750	m
GENERATOR		
Generator Speed	360.0	rpm
Number of Generator Poles per Unit	20	
Rotor Weight per Unit	19	Tonnes

REFERENCES

REFERENCES

(1) Acres Consulting Services Limited. 1984. "Hydrologic Design Methodologies for Small-scale Hydro at Ungauged Sites - Phase I". Environment Canada, Inland Waters Directorate - Atlantic Region, and Energy, Mines and Resources, Canada.

(2) Acres International Limited. 1985. "Hydrologic Design Methodologies for Small-scale Hydro at Ungauged sites - Phase II". Feasibility level study for Atlantic Provinces. Environment Canada, Inland Waters Directorate - Atlantic Region, and Energy, Mines and Resources, Canada.

(3) Charles Howard & Associates Limited. 1986. "Report on Hydrologic Design Methodologies for Small-scale Hydro at Ungauged Sites in British Columbia". IMP - An integrated method for power analysis. Environment Canada, Inland Waters Directorate, and Energy Mines and Resources Canada.

(4) Monenco Limited. 1984. "Identification of Environmentally Compatible Small-scale Hydroelectric Potential in Atlantic Canada - Phase I New Brunswick and Prince Edward Island". A report to Environment Canada, Energy, Mines and Resources, Canada, and Supply and Services, Canada.

(5) CEA Report No. 712 G688. "Hydroelectric Turbine Assessment for New Units and Runner Retrofits". A report to The Canadian Electrical Association by Monenco Consultants Ltd. on Development of New Equations and Guidelines for Sizing New Turbine Units and Runner Retrofits.

APPENDIX I

BACKGROUND OF SHYDRO

APPENDIX I

BACKGROUND OF SHYDRO

SHYDRO-VERSION 3 is a costing model for micro and small hydro developments. It is based largely on a set of parametric costing equations originally developed by Monenco Limited, for implementation on the DEC 20 mainframe (1984) and later adapted for IBM-PC and compatibles and marketed under the name SHYDRO-PC.

SHYDRO-VERSION 3 is essentially an update of SHYDRO-PC. THis update retains the original basis of SHYDRO-PC but incorporates a series of features designed to enhance the versatility of the program. Additionally, the model has bene extended to incorporate a power canal with canal spillway and upstream control structure. The program has been expanded in Version 3.2 to provide additional data on major powerhouse equipment to assist the user in further layout and cost study.

The formulae and cost relationships used in SHYDRO are explained in the following sections.

Project Cost Estimation

The SHYDRO Program calculates the cost of the following components:

- Dam and Spillway
- Control Structure
- Power Canal
- Penstock
- Unwatering
- Powerhouse Civil
- Equipment Supply and Reaction
- Access Road
- Transmission Line and Substation
- Fishway (where required)
- Contractor's Overhead
- Engineering and Owner's Cost
- Interest During Construction
- Optional Cost

.1 Costs Not Included

The following costs have not been included in the project cost estimate:

.1 Land purchase;

.2 Land clearing;

.3 Relocation of roads, railways, powerlines, bridges, due to reservoir flooding, etc.; and

.1 Costs Not Included (Cont'd)

.4 Relocation or purchase of buildings affected by reservoir flooding.

.2 Dam and Spillway Cost

Input parameters used to estimate the cost of the dam are height of dam, length of dam, and base unit price. The formula for cost of dam has the form:

$$\text{Cost of Dam} = K * C_s (V * A_d * L)^Y$$

where
- K = a constant
- C_s = base unit price
- V = valley shape factor
- A_d = maximum cross-sectional area
- L = dam length
- Y = exponential factor

[For timber crib, earthfill and rockfill dams].

The valley shape factor represents the ratio between the maximum dam volume based on the maximum dam section and the actual dam volume based on the site topography. A U-shaped valley would have a factor approaching 1.0, while a V-shaped valley would have a factor of approximately 0.4. A valley shape factor of 0.55 is used in the current version of the SHYDRO program. If local topography dictates the use of another shape factor, modifications are required for each of the dam formulae used within the program.

Four dam types are considered, with the computer program estimating the cost of each type and using the lowest price alterative. Dam types considered and their applicable dam height and cross-sectional characteristics are summarized below.

"A" frame dams are only considered in micro hydro applications where capacity < 250 kW and H < 2.50 m.

	Height Range (m)	Crest Width (m)	U/S Slope	D/S Slope
Timber Crib	8.0	1.2	1:1	1:4
Concrete (gravity)	16.0	1.0	vertical	0.75:1
Earthfill (with concrete)	all	8.0	3:1	2.5:1

.2 Dam and Spillway Cost (Cont'd)

An exponential reduction in unit price is used in the program to compensate for economy of scale for larger dam volumes. The following base quantities are used for determining the appropriate unit prices:

	Base Quantity m^3
Rock Excavation	2000
Earthfill Dam	5000
Concrete Dam	1000
Timber Crib Dam	800

The Program estimates the dam cost on the basis of the following formulae:

"A" Frame Dam

Applied when installed capacity $\leq$250 kW and dam height <2.50m.

Cost of "A" Frame Dam = F1*L*D*200

where: F1 = equipment adjustment factor
L = length of dam
D = height of dam

Timber Crib

Cost of Timber Crib Dam = $1.4*C_1(V*A*L)^{0.95}$

where C_1 = timber crib unit price
A = maximum cross-sectional area
L = dam crest length
V = valley shape factor

Concrete

Cost of Concrete Dam = $2.0*C_2*(V*A*L)^{0.9}$

where C_2 = concrete dam unit price

Earthfill

Cost of Earthfill Dam (with volume $\leq$ 15000 m^3)
= $26.9*EEX(V*A_1*L)^{0.70}$

.2 Dam and Spillway Cost (Cont'd)

Cost of Earthfill Dam (with volume > 15000 m^3)

$$= 3.9*EEX(V*A_1*L)^{0.90}$$

where EEX = earthfill unit price for excavation [program and 50% to excavation cost to cover haulage and compaction in fill structures]

A_1 = maximum cross section area based on height 4.0m above spillway crest

Spillway

The input parameters used to estimate the cost of the spillway are flood flow, dam height, and base unit price. For the purposes of standardizing the basis of estimating the cost for inventory purposes, a concrete chute spillway with a chute length three times the dam height was selected. The cost formula has the form:

Cost of Spillway $= C_3*[F*3(D + 4)]^{0.78}$

where C_3 = base unit price for spillway concrete
D = maximum height to spillway crest plus 4.0
F = flood flow

The unit price is exponentially reduced for larger spillway due to economies of scale and has a base unit price which is determined from a representative quantity of 1000 m^3.

Control Structure

Cost of control structure

$$= C3*[40 + (11.0 + 3*DD)*Q]$$

where DD = draw down in reservoir
Q = plant flow capacity
C3 = spillway concrete

Power Canal

Four basic geometrical designs are provided as shown in Figure I-1. The program fits the appropriate design to the given site conditions. When the power canal connects the reservoir to the intake without a control structure the height of the dykes is adjusted to handle the specified freeboard. In this case no canal spillway is required. When the canal is downstream of a control structure, water level in the canal is assumed to the held constant and drawdown is set to zero. However, in this situation a canal spillway, sized to handle the plant flow capacity, is provided.

.2 Dam and Spillway Cost (Cont'd)

In all designs the minimum water area is based on a maximum allowable velocity of 0.6 m/s chosen to ensure formation of an ice cover under winter operation.

Canal cost = [EEX*AC + REX*AR + 0.167 (EEX + REX)*AF]*CL + INDIC*(0.3*C3 + 9.0*REX)*Q

where EEX = unit cost earth excavation
REX = unit cost rock excavation
C3 = unit cost spillway concrete
AC = area earth cut
AR = area rock cut
CL = length of canal
Q = plant flow capacity
INDIC = 0 no control structure
1 control structure

Intake

The site-related input parameters required for estimating the cost of the intake are the design flow, number of units, and unit prices for earthwork and concrete. The intake cost formula is:

Cost of Intake = $U*1.12*(190EEX + 37.5C_3)*(Q/U)^{0.9}$

where C_3 = unit price for spillway concrete
EEX = unit price for excavation
Q = design flow
U = number of units

.3 Penstock Cost

Several penstock design options are examined, as follows:

Design Type	Range of Application
Above Ground:	
- Steel	P1 > 0.3 m
- Polyethylene	Feasible when P1 < 1.0m and H < (122 - 77*P1)m

.3 Penstock Cost (Cont'd)

Below Ground:

-	Steel	P1 > 0.3 m
-	Polyethylene	As above
-	Fibre glass reinforced Plastic	0.5 m < P1 $\leq$ 2.5 m and H $\leq$ 60 m

Where P1 = penstock diameter
H = head

When buried designs are specified by the user the computer will automatically select the lowest cost feasible alternative form steel, polyethylene and fibre glass reinforced plastic designs. Where surface designs are specified two designs are considered - steel and polyethylene, and the computer selects the lowest cost feasible alterative.

The input parameters and calculated data required for calculation of penstock cost are the penstock length, rated head, unit prices for earthwork, and computed diameter.

A sub-routine within the program calculate the economic penstock diameter. The economic diameter is calculated using the following formula (Reference: Fahlbusch, "Power Tunnels and Penstocks: The Economics Re-Examined. Water Power and Dam Construction, June 1982).

$$\text{Penstock Diameter } (P_1) = (F2)^{0.143} * 1.26 * \frac{(Q/U)^{0.43}}{H^{0.14}}$$

where Q = design flow
H = rated head
U = number of units
F2 = fuel factor = $\frac{\text{(cost of diesel fuel in mills/kWh)}}{\text{(cost of bunker "C" in mills/kWh)}}$

Polyethylene (Buried)

$$\text{Cost} = P*U*(F1*800*P_1^2 + 0.65*EEX)$$

where P = penstock length
U = number of units
EEX = unit price for earth excavation
P_1 = penstock diameter

.3 Penstock Cost (Cont'd)

Polyethylene (Surface)

$$\text{Cost} = P*U*F1*313(P_1 + 0.03) + P\,(0.5 + 0.5\,U)\,(1.2EEX + 0.3REX)$$

where F1 = equipment cost adjustment factor
EEX = unit cost earth excavation
REX = unit cost rock excavation
P, P_1 and U as above

Steel

Minimum penstock thickness (mm)

$$P2 = 7.5 + \frac{P1}{0.8}$$

Maximum penstock thickness (mm)

$$TAX = 0.0405*H*P1 + 2.5$$

Average penstock thickness (mm)

$$TAV = [TMAX^2 + P2^2]/[2TMAX]$$

For design thickness, P2

use P2 = P2 when TMAX < P2
use P2 = TAV when TMAX $\geq$ P2

Steel (Buried)

$$\text{Cost} = P*U[F1*109*P1*P2 + 1.25EEX*P1(P1 + 1.5) + 0.65*EEX*(P1 + 1.5)^2]$$

Steel (Surface)

$$\text{Cost} = P*U*F1*0.082*P2(1000P1 + P2) + P*U*0.09*C3*P1^2 + P(0.5 + 0.5U)*0.60(EEX + REX)*P1^2$$

where P2 = minimum thickness or design thickness
TMAX = maximum thickness from hoop stress formula
REX = unit cost of rock excavation
P1, U, C3, EEX = as previously defined

Fibreglass

Cost of fibreglass penstock

$$= P*U[F1*460*P1 + 1.25*EEX(P1 + 0.6)(0.5P1 + 0.5) + 2.0*EEX(0.5P1)^2]$$

.4 Unwatering Cost

Unwatering concepts are site specific and depend largely on the site topography and plant layout. Several alternatives can be considered when providing an allowance for the cost of unwatering, such as cofferdams, pumping and diversion work. A relationship between the diversion flow at a site and the cost of unwatering has been developed. It must be emphasized that this is merely an expedient used to arrive at a reasonable sum of money for unwatering.

For timber crib, concrete and earthfill dams, the diversion flow selected approximates the ten-year flood and is estimated in the Program by factoring the flood flow. The diversion flow is given to be 50 percent of the flood flow. Variations for different hydrological regions will require modification of the unwatering formula.

Cost of Unwatering = 100*EEX*(0.5*F)

where EEX = unit price for earth excavation
F = flood flow

For "A" Frame Dams, which would be built on very small streams, elaborate measures for unwatering would not normally be required. In this case unwatering costs are taken as a proportion of dam cost.

Cost of Unwatering = 0.15*cost of "A" Frame Dam

.5 Powerhouse Costs

Three parametric equations for total powerhouse costs have developed giving total powerhouse cost (including direct and indirect costs) as a function of installed capacity and plant head. Powerhouse civil works, equipment supply and erection costs are then estimated as fractions of total powerhouse cost. The basic equations express powerhouse cost in 1986 Canadian dollars. An equipment cost adjustment factor (F1) must be supplied by the user to adjust for cost escalation of equipment, while the program calculates a civil cost adjustment factor (F3) for adjusting the civil work costs.

The cost of a pressure relief is added whenever the penstock, length/head ratio, is greater than 8.0. This is done by adjusting the equipment supply and erection cost by a factory of *1.12 (increase in civil cost is assumed to be minimal).

Civil escalation factor $F3 = \frac{C3}{500}$

.5 Powerhouse Costs (Cont'd)

For Installed Capacities $\leq$ 250 kW

$$\text{Powerhouse Direct Cost, ZTOT} = 1.01*10^{6}*\frac{(MW)^{0.6}}{H^{0.25}}$$

Powerhouse Civil, Z6 = F3*0.3*ZTOT
Equipment Supply, Z7 = F1*0.5*ZTOT*FACTOR
Equipment Erection, Z8 = 0.40*Z7

For Installed Capacities 250 kW < MW < 5.0 MW

$$\text{Total Powerhouse Cost, ZTOT} = 5.55*10^{6}*\frac{(MW)^{0.7}}{H^{0.35}}$$

Powerhouse Civil, Z6 = F3*0.17*ZTOT
Equipment Supply, Z7 = F1*0.35*ZTOT*FACTOR
Equipment Erection, Z8 = 0.3*Z7

For Installed Capacities MW $\geq$ 5.0 MW

$$\text{Total Powerhouse Cost, ZTOT} = \frac{4.00*10^{6}*(MW)^{0.92}}{H^{J}}$$

where $J = 0.32\ (MW)^{0.058}$

Powerhouse Civil, Z6 = F3*0.17*ZTOT
Equipment Supply, Z7 = F1*0.34*ZTOT*FACTOR
Equipment Erection, Z8 = 0.3*Z7

where: F1 = equipment cost adjustment factor
F3 = civil escalation factor
FACTOR = *1.00 no pressure relief valve
= *1.12 pressure relief valve added
MW = installed capacity
H = design head

.6 Access Road Cost

The input parameters required for costing the access road are its length and base unit price. An average unit cost for constructing the access road is estimated on the basis of a length of road of 5 km. Allowance was made for exponential reduction of the unit cost for longer access roads:

$$\text{Cost of Access Road} = 1.27*C_{,}*(A)^{0.85}$$

where $C_{,}$ = access road unit price
A = access road length

.7 Transmission Line and Substation Costs

Transmission Line

Input parameters and calculated data used to estimate the cost of the transmission line are installed capacity and transmission line length. The transmission line cost in 1986 Canadian dollars is given in the parametric cost relationship below. These costs are adjusted for escalation since 1986 by an adjustment factor,

F4 = [0.5F1 + 0.05EEX]

Cost of Transmission Line (for installed capacity < 1 MW)

= F4*39000T

where T = transmission line length (km)

Cost of Transmission Line (for installed capacity $\geq$ (MW)

$= F4*8800[4.28 + (MW-1)^{0.5}]*MW^{0.1}*T^{0.9}$

Substation

Substation costs have been included in the powerhouse equipment costs for plants with installed capacities greater than or equal to 5.0 MW.

The installed capacity is the basis for estimating the cost of substations for sites smaller than 5.0 MW. The formula used for estimating the cost of substations is:

$\text{Substation Cost} = F1*1350*(MW*1000)^{0.6}$

8. Fishway Cost

Input data required for calculation of the fishway cost, if required, are the dam height unit cost and fishway factor.

$\text{Fishway Cost} = C_s*D*S_2$

where C_s = unit price
D = dam height to spillway crest
S_2 = fishway factor

Optional Cost Item

The program allows for the inclusion of an optional cost item and identifying label, in the direct cost table. This cost item would be unique to the scheme under study.

.9 Contractor's Overhead Cost

The estimate for contractor's overhead cost reflects the remoteness of the site and the cost of transportation and travel. The upper limit of this component is set at 40 percent of the cost of the following work:

- dam unwatering
- intake
- dam and spillway
- penstock earthwork
- powerhouse civil
- access road
- fishway (if required)

Input data used to calculate this component are the distance to the nearest concrete plant an the distance to the nearest town. The formula for the cost of the contractor's overhead cost has the form:

$$\text{Contractor's Overhead Cost} = (0.005R_1 + 0.001R_2)B \quad \text{or} \quad 0.04\ (B) \quad \text{whichever is less}$$

where B = cost of the above components which reflect the remoteness of site
R_1 = distance to nearest town
R_2 = distance to nearest concrete plant

.10 Engineering and Owner's Costs

Engineering and Owner's costs are estimated as a sliding-scale percentage of the total project cost, excluding interest during construction. The estimating formula has the form:

$$\text{Engineering and Owner's Cost} = 0.60*(E)^{0.89}$$

where E = project cost, excluding interest during construction

.11 Interest During Construction

The cost of interest during construction is dependent on the project cost, length of construction and the interest rate based on the real cost of money. A formula for construction time based on the installed capacity has been developed. A real interest rate of 6 percent has been used in the formula development. The formula for the cost of interest during construction has the form:

.11 Interest During Construction (Cont'd)

Cost of Interest During Construction $\frac{R*0.06*C}{2}$

where R = construction time
C = capital cost of development

A formula for construction time, based on the installed capacity is given as:

For installed capacities less than 5 MW:
Construction Time (R) = $0.172\ (MW*1000)^{0.25}$

For installed capacities greater than or equal to 5 MW:
Construction Time (R) = $0.0134\ (MW*1000)^{0.55}$

.12 Total Project Cost

The SHYDRO Program accumulates the above costs to obtain the total project cost.

The Program has been tested against small-scale hydro project costs and has been found to estimate the project cost within 10 percent of the construction plant cost. However, due to unrealibility of the input data, the computed costs can only be regarded as having an accuracy in the region of 25 to 50 percent.

Benefit/Cost Ratio

The Program calculates a simple benefit/cost ratio which can be used for preliminary screening and ranking of sites.

Annual Cost

Input data required for estimation of the annual cost are the interest rate and the operating maintenance percentage. The formula for estimating the annual cost is as follows:

Annual Cost = $G*(I + C_q)/100$

where G = total project cost
I = interest rate
C_q = operating and maintenance cost as percentage of capital cost

Annual Benefit

Input data required to estimate the annual benefit include the available turbine flow ratio, maximum turbine flow ratio, installed capacity, and the value of generated power. the formula used for estimating the annual benefit is as follows:

.12 Total Project Cost (Cont'd)

Annual Benefit = $(Q_1/Q_2 * MW * 8760 * M_1$

where Q_1 = useable flow ratio
Q_2 = plant design flow ratio
MW = installed capacity
M_1 = value of power generated ($/MW.hr)

.13 Powerhouse Equipment Data

Input

User input required for calculating turbine and generator data directly from SHYDRO are:

H - Gross Head
U - Number of Units
TWE - Tailwater Elevation

Sub-Routines

Sub-routines within the program calculate the following:

KW - Plant Capacity (From installed capacity)
NETH - Net Head (set at 94% of H)
Q_T - Turbine Flow per Unit (0.116 * KW/NETH/U)
Q_3 - Plant Capacity Factor (usable Flow (Q_1)/Plant Design Flow (Q_2))
BARP - Barometric Pressure ($10.2 - 0.002 \times TWE^{0.92}$)
BLADES - Number of Runner Blades (See Selection Table)
DTF - Draft Tube Factor (See Selection Table)
POLES - Generator Poles (Multiple of 4)
GSPEED - Generator Speed

The following additional parameters required for turbine - generator sizing are pre-set or are otherwise selected using the following criteria:

RMF - Runner Material Factor
Pre-set at 4.5 for stainless steel.

FREQ - System Frequency. Pre-set at 60 cycles per second.

TSUB - Turbine submergency (see Fig. I-2 in Appendix I). Most small hydro plant have unit set about 2.0 meters above tailwater, i.e. submergency = -2.0 m. This should be used for preliminary calculations. The user may then select another setting between -3.0 and +3.0 depending on suppliers recommendation, tailwater fluctuations or runner service requirements.

.13 Powerhouse Equipment Data (Cont'd)

Subroutines for BLADES & DTF are based on the following selection ranges:

H (m)	BLADES	DTF
$H \leq 8$	4	0.01
$8 < H \leq 16$	6	0.01
$16 < H \leq 100$	13	0.02
$100 < H \leq 200$	15	0.02
$200 < H \leq 300$	17	0.02
$H > 300$	19	0.02

Subroutine for shaft orientation is based on the following:

For NETH > 16m and Turbine Throat Diameter (TTD) > 1.8m vertical shaft is used. Otherwise horizontal shaft is used.

Runner Throat Velocity (RTV)

The equation for estimating Runner Throat Velocity is as follows:

$$RTV = 1.49 * BLADES^{0.28} (TSUB + BARP + RMF - 5.0 - 2.3\ Q_3)^{0.5}$$

Where BLADES = Number of runner blades
TSUB = Turbine submergency
BARP = Barometric pressure
RMF = runner material factor
Q_3 = plant capacity factor

Turbine Throat Diameter (TTD)

The equation for calculating Turbine Throat Diameter is as follows:

$$TTD = 1.128\ (Q_T/RTV)^{0.5}$$

Where Q_T = turbine flow
RTV = runner throat velocity

Runner Speed (RSPEED)

The equation for calculating Runner Speed is as follows:

$$RSPEED = \frac{1000\ [NETH - (DTF * RTV)^2]^{0.32}}{TTD^{0.9} * RTV^{0.45} * BLADES^{0.36}}$$

.13 Powerhouse Equipment Data (Cont'd)

Where NETH = net head
DTF = draft tube factor
RTV = runner throat velocity
TTD = turbine throat diameter
BLADES = number of runner blades

Generator Speed and Gear Box Subroutine

A subroutine has been incorporated in the program to establish a synchronous speed for the generator and to determine if a gear box should be used.

- Gear Box Case

  If KW < 1000 and RSPEED < 200 a gear box is used. Also, if KW < 500 and RSPEED > 100, GSPEED is set at 900 rpm, otherwise GSPEED is set at 600 rpm.

  POLES = 120 x FREQ/GSPEED

  Where FREQ = system frequency (set at 60 cycles/sec)
  GSPEED = generator speed (900 or 600 rpm)

  Note - with gear box, RSPEED will remain as originally calculated.

- No Gear Box

  If KW and RSPEED are not suitable for gear box, a synchronous speed will be selected for GSPEED as follows:

  The theoretical number of poles (POLES) required is checked using the following equation:

  $$\text{POLES (check)} = \frac{120 * \text{FREQ}}{\text{RSPEED}}$$

  Where FREQ = system frequency (set at 60)
  RSPEED = calculated turbine runner speed

  If POLES (check) <4 POLES selected = 4

  Where POLES (check) >4, the closet multiple of 4 is selected and Generator Speed (GSPEED) calculated using the following equation:

  GSPEED = 120 * FREQ/POLES

  Where POLES = Number of poles selected

.13 Powerhouse Equipment Data (Cont'd)

With no gear box, runner speed (RSPEED) must be equal to generator synchronous speed (GSPEED). This adjustment is made by the program following selection of the synchronous speed.

Generator Rotor Weight

The estimated generator rotor weight (RWEIGHT) is calculated by the following equation:

$$RWEIGHT = 50 * MVA^{0.74}/GSPEED^{0.37}$$

Where MVA = rated generator capacity (KW/1000/0.9)

.14 Least Cost of Development

A simple methodology was developed for checking the first order of magnitude costs for hydro projects, based on a statistical analysis of cost data obtained from over 170 projects ("Hydropower Cost Estimates", by J.L. Gordon, Water Power, November, 1983).

It is well known that project costs per unit of installed capacity tend to decrease with increasing capacity, and that powerhouse costs for a fixed capacity tend to decrease with increasing head. Hence, it is to be expected that total project costs, including all overheads, but excluding transmission cost, should tend to be a function of $(MW/H^x)^Y$, where MW is the installed capacity, H is the project head, and x and y are unknown components.

There are many other factors which affect project costs, such as the project layout, site location, spillway capacity and foundation conditions. However, if these are disregarded for this initial evaluation, an estimate for the values for x and y can be obtained form historical costs.

The least (minimum) cost for small-scale hydro development, based on the 1983 work of Gordon, is given as follows:

$$\text{Least Cost (\$Can. 1986)} = 8.3 * 10^6 * (M/H^{0.3})^{0.82}$$

where M = installed capacity (kW)/1000
H = gross head

The cost of approximately 20 micro and mini-hydro projects in rural Canadian communities have recently been analyzed and the least cost based on these projects can be given as:

.14 Least Cost of Development (Cont'd)

Least Cost ($Can.1986) = 2350 * $(kW/H^{0.3})^{1.25}$

where kW = Installed Capacity
H = gross head

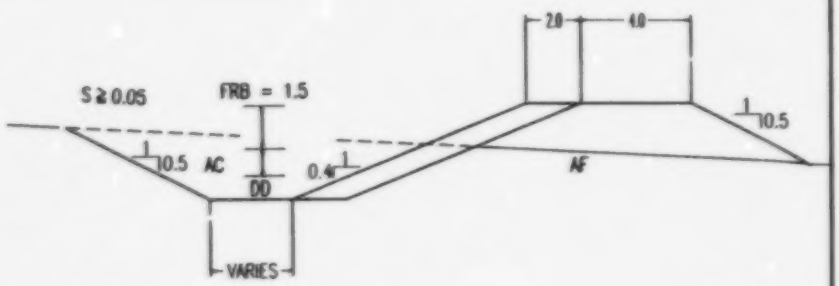
This latter formula has been determined to apply to mini/micro sites with a $kW/H^{0.3}$ ratio less than 338. Selection of the applicable formula is made by the program on the basis of this ratio.

The formulae represent the probable minimum cost of development for a small-scale hydro project with preferred site characteristics. The formulae is intended primarily for projects under 10 MW capacity and does not include transmission costs or interest during construction. The formulae cannot, at this time, be used with confidence for estimation of the capital cost of development.

The "least cost" formulae are used as a check of the SHYDRO program cost. If the latter was found to be lower, then the site-specific input parameters must be checked to determine the reason for the apparent lower cost.

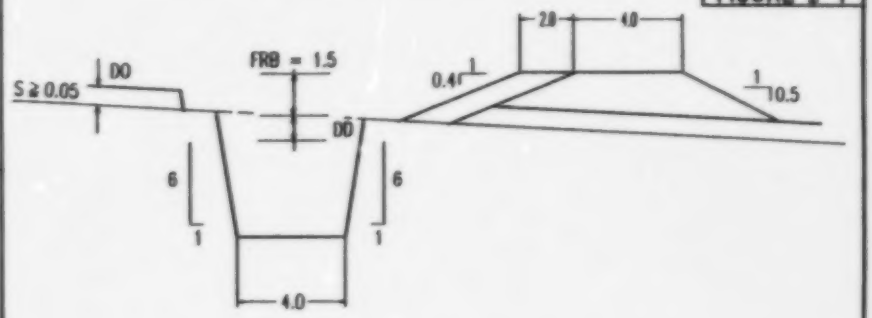
Note: The example used in the tutorial run, in fact, indicates a "least cost" higher than the project cost. In actual practice this case would therefore be subject to review of the input parameters.

FIGURE 1-1



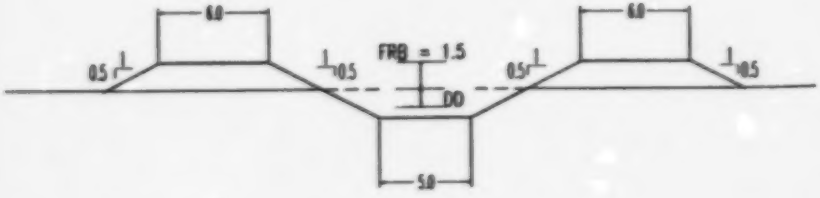
AF = 0.5 AC

CANALS IN EARTH, SLOPE ≧ 0.05



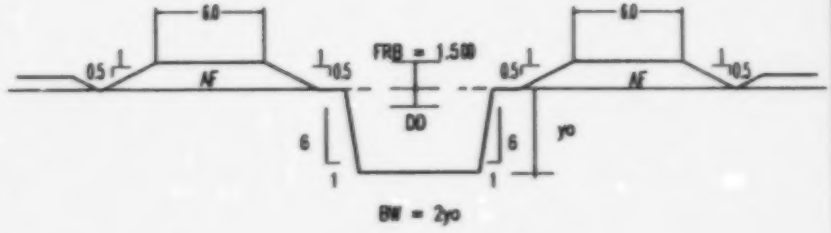
AF = 0.5 (AC + AR)

CANALS IN ROCK, SLOPE ≧ 0.05



AF = 0.35AC

CANALS IN EARTH, SLOPE < 0.05



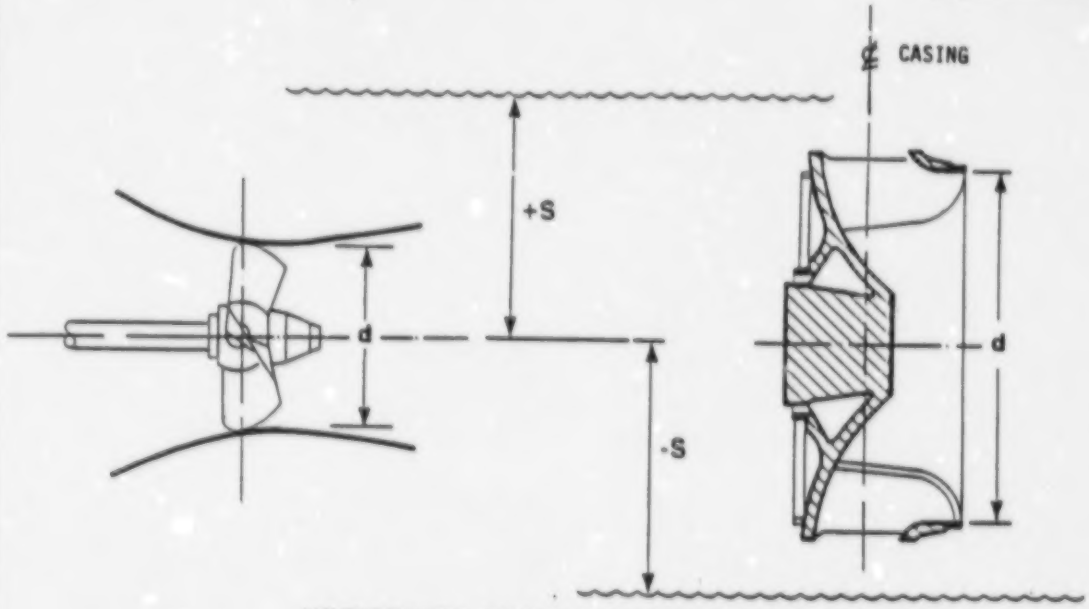
BW = 2yo

AF = 0.35AC + 0.5AR

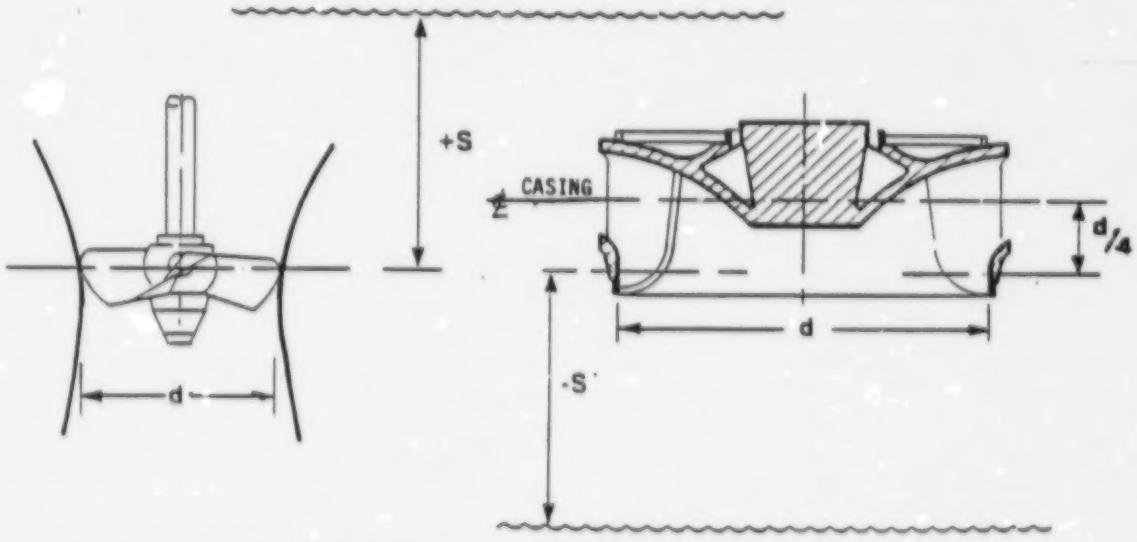
CANALS IN ROCK, SLOPE < 0.05

(Note: All units in m)

FIGURE I-2



HORIZONTAL SHAFT SUBMERGENCE MEASUREMENT



VERTICAL SHAFT SUBMERGENCE MEASUREMENT

Schematic showing method of measuring turbine submergence.

S = Turbine Submergence (TSUB)
d = Turbine Throat Diameter (TTD)

APPENIDIX II

PROGRAM LISTING

```
80  REM ************************************************************************
90  REM *                                                                      *
100 REM *          PROGRAM SHYDRO-PC ( VERSION 3.2, MARCH  1991 )              *
110 REM *                 SHAWMONT NEWFOUNDLAND LIMITED                        *
120 REM *                    St.JOHN'S,NEWFOUNDLAND                            *
130 REM *                       TEL 709 754 0250                               *
140 REM *                                                                      *
150 REM *----------------------------------------------------------------------*
155 REM *                                                                      *
160 REM *    SHYDRO  was  originally written in BASIC for a DEC 20 computer    *
170 REM *  running under the TOPS 20 operating system. Version 3.2 has been    *
180 REM *  rewritten to run on an IBM PC  or look-a-like running DOS 2.1 or    *
190 REM *  greater. SHYDRO is menu driven and it is hoped self explaintory.    *
200 REM *  On-line help does exist if needed.  The user can access the  on-    *
210 REM *  line help by pressing the key marked <F10>.                         *
220 REM *                                                                      *
221 REM *                                                                      *
222 REM *                    Programmed by: Hayward J. Keats                   *
223 REM *                    Latest Update: March 27, 1991                     *
230 REM ************************************************************************
240 WIDTH 80: WIDTH "LPT1:", 132                    'set screen and printer width
245 DEFDBL C, E, G, P, T-V, Y-Z
250 KEY OFF
260 DIM C$(40), C(40)
270 B$ = "
  "
280 ON ERROR GOTO 7820
290 REM ********************** DEFINE SOFTKEYS FOR MENU CHOICES *****************
300 KEY 1, "1" + CHR$(13)
310 KEY 2, "2" + CHR$(13)
320 KEY 3, "3" + CHR$(13)
330 KEY 4, "4" + CHR$(13)
340 KEY 5, "5" + CHR$(13)
350 KEY 6, "6" + CHR$(13)
360 KEY 7, "7" + CHR$(13)
370 KEY 8, "8" + CHR$(13)
380 KEY 9, "9" + CHR$(13)
390 KEY 10, "10" + CHR$(13)
400 REM ***************** DEFINE PROMPTS FOR DATA INPUT ************************
410 C$(1) = "TIMBER CRIB WORK    ($/m^3)"
420 C$(2) = "DAM CONCRETE        ($/m^3)"
430 C$(3) = "SPILLWAY CONCRETE   ($/m^3)"
440 C$(4) = "EARTH EXCAVATION    ($/m^3)"
450 C$(5) = "ROCK EXCAVATION     ($/m^3)"
460 C$(6) = "ACCESS ROAD          ($/km)"
470 C$(7) = "FISHWAY     ($/m OF DAM HT)"
480 C$(8) = "INTEREST RATE            (%)"
490 C$(9) = "O & M COST    (% PER ANNUM)"
500 C$(10) = "REVENUE              ($/MWh)"
510 C$(11) = "EQUIP. ADJUSTMENT FACTOR   "
520 C$(12) = "FUEL FACTOR                "
530 C$(13) = "FISHWAY         Y =1 / N =0 "
540 C$(14) = "FLOOD FLOW          (m^3/s)"
550 C$(15) = "PLANT DESIGN FLOW RATIO    "
```

```
560 C$(16) = "USEABLE FLOW RATIO          "
566 C$(17) = "TURBINE SUBMERGENCE         "
570 C$(18) = "ADDITIONAL COST x $1000     "
580 C$(19) = "GROSS HEAD              (m)"
590 C$(20) = "DAM HEIGHT              (m)"
600 C$(21) = "DAM LENGTH              (m)"
610 C$(22) = "DRAWDOWN                (m)"
620 C$(23) = "CANAL LENGTH            (m)"
630 C$(24) = "   TRANSVERSE SLOPE         "
640 C$(25) = "   OVER BURDEN DEPTH    (m)"
650 C$(26) = "PENSTOCK LENGTH         (m)"
660 C$(27) = "   SURFACE =1 / BURIED =0"
670 C$(28) = "AVERAGE FLOW        (m^3/s)"
680 C$(29) = "NUMBER OF UNITS             "
690 C$(30) = "TRANSMISSION LINE LENGTH    "
700 C$(31) = "ACCESS ROAD LENGTH     (km)"
710 C$(32) = "DISTANCE TO TOWN       (km)"
720 C$(33) = "DIST. TO CONC. PLANT   (km)"
730 C$(34) = "CONTROL STRUCTURE Y=1/N=0"
735 C$(35) = "TAILWATER ELEVATION         "
750 C$(36) = "WATER SHED"
760 C$(37) = "SITE NUMBER"
770 W$ = "(Name of)"
780 S$ = "(Name of)"
790 GOSUB 6860                          ' MAIN MENU PROMPT
800 GOSUB 6910
810 HELP = 1
820 REM ******************** JUMP TABLE FOR MENU CHOICES *************************
840 ON CHOICE GOSUB 860, 1010, 1180, 2410, 2870, 2940, 3010, 3030, 3150, 6550
850 GOTO 790
860 REM ********************** INPUT MAIN VALUES FOR SHYDRO ***********************
870 CLS
880 GOSUB 6860
890 COLOR 0, 7: LOCATE 4, 2: PRINT "------------ Cost Data ------------ INPUT MENU ---
------- Site Data -----------";
900 COLOR 7, 0
910 FOR I = 1 TO 18
920   LOCATE I + 4, 1: PRINT USING "##) \                          \#######.##"; I; C$(
I); C(I);
930   LOCATE I + 4, 45: PRINT USING "##) \                       \#####.##"; I + 18; C$
(I + 18); C(I + 18);
940 NEXT I
950 LOCATE 22, 45: PRINT USING "36) \          \\                \"; C$(36); W$;
960 LOCATE 23, 45: PRINT USING "37) \          \\                \"; C$(37); S$;
970 GOSUB 7290
980 KEY 10, "10" + CHR$(13)
990 IF (A$ = "F") OR (A$ = "f") THEN RETURN
1000 RETURN
1010 REM ************************ CONSTANT ASSIGNMENT ****************************
1030 REM ************ ASSIGN THE COST PARAMETERS TO THESE DEFAULT VALUES ******
1040 C(1) = 300
1050 C(2) = 400
1060 C(3) = 500
1070 C(4) = 10
```

```
1080 C(5) = 20
1090 C(6) = 60000!
1100 C(7) = 41000!
1110 C(8) = 10
1120 C(9) = 1.5
1130 C(10) = 100!
1140 C(11) = 1
1150 C(12) = 1
1160 CLS : LOCATE 13, 13: COLOR 0, 7: PRINT "  COST DEFAULT VALUES ASSIGNED CHANGE VIA
 <F1> IF DESIRED  "; : COLOR 7, 0: GOSUB 7130: RETURN
1170 RETURN
1180 REM ************************ PRINTER SUBROUTINE ******************************
1190 IF KODE = 2 GOTO 1220
1200 CLS : LOCATE 12, 19: COLOR 0, 7: PRINT "  CALCULATION UNIT HAS NOT BEEN RUN PRESS
 F9  "; : COLOR 7, 0
1210 GOSUB 7130: RETURN
1220 REM
1230 LPRINT TAB(26); "SHYDRO-PC  VERSION 3.2  MARCH  1991": LPRINT : LPRINT
1240 LPRINT TAB(30); "        DATA SHEET        ": LPRINT
1250 LPRINT TAB(32); "   DATE : "; DATE$: LPRINT : LPRINT : LPRINT
1260 LPRINT "       WATER SHED : "; W$
1270 LPRINT "       ------------"
1280 LPRINT "       SITE NAME : "; S$
1290 LPRINT "       -----------"
1295 LPRINT "       FILE : "; F$
1296 LPRINT "       ------"
1300 IF T <= 10 * M THEN 1330
1310 LPRINT "       NOTE - TRANSMISSION LINE LENGTH EXCEEDS 10*MW"
1320 GOTO 1340
1330 LPRINT
1340 IF P >= 20 * H THEN 1350 ELSE 1360
1350 LPRINT "       NOTE - PENSTOCK LENGTH EXCEEDS 20 * HEAD (SURGE TANK MAY BE REQUIR
ED)": GOTO 1380
1360 IF P >= 8 * H THEN 1370 ELSE 1380
1370 LPRINT "       NOTE - PENSTOCK LENGTH EXCEEDS 8 * HEAD (PRESSURE RELIEF VALVE ADD
ED)"
1380 LPRINT : LPRINT "       SITE DATA"
1390 LPRINT "       ---------"
1400 LPRINT USING "              INSTALLED CAPACITY                              ##,###.
###" + " kW"; M * 1000
1410 LPRINT USING "              NUMBER OF UNITS                                 #
###"; U
1420 LPRINT USING "              GROSS HEAD                                      #.###
.##" + " m"; H
1424 LPRINT USING "              TAILWATER ELEVATION                             ##.###
.##" + " m"; TWE
1426 LPRINT USING "              TURBINE SUBMERGENCE                             ##.###
.##" + " m"; TSUB
1430 LPRINT USING "              AVERAGE FLOW                                    ##.###
.##" + " m^3/s"; C(28)
1440 LPRINT USING "              FLOOD FLOW                                      ###.
###" + " m^3/s"; F
1450 LPRINT USING "              PLANT DESIGN FLOW RATIO                         ###.###
.##"; Q2
```

```
1460 LPRINT USING "              USEABLE FLOW RATIO                    ###.###
.##"; Q1
1470 LPRINT USING "              HEIGHT OF DAM                          #.###
.##" + " m"; D
1480 LPRINT USING "              LENGTH OF DAM                       ##,###.###
.##" + " m"; L
1490 IF CL <= 0 THEN 1540
1500 LPRINT USING "              DRAWDOWN (F.S.L. - L.S.L.)               ###
.##" + " m"; DD
1510 LPRINT USING "              CANAL LENGTH                           #.###.
###" + " m"; CL
1520 LPRINT USING "              CANAL MEAN TRANSVERSE SLOPE              ####
.##"; SS
1530 LPRINT USING "              CANAL DEPTH OF OVER BURDEN               ###
.##" + " m"; DOB
1540 IF PT = 1 THEN PT$ = "(SURFACE)" ELSE PT$ = "(BURIED) "
1550 LPRINT USING "              PENSTOCK LENGTH " + PT$ + "            #.###.#
##.##" + " m"; P
1570 LPRINT USING "              TRANSMISSION LINE LENGTH               ##.###
.##" + " km"; T
1580 LPRINT USING "              ACCESS ROAD LENGTH                     ##.###
.##" + " km"; A
1590 LPRINT USING "              DISTANCE TO TOWN                       ##.###
.##" + " km"; R1
1600 LPRINT USING "              DISTANCE TO CONCRETE PLANT             ##.###
.##" + " km"; R2
1610 LPRINT
1620 LPRINT "      UNIT COST DATA":
1630 LPRINT "      ---------------"
1640 LPRINT USING "              TIMBER CRIB WORK                       ##.###
.##" + " m^3"; C1
1650 LPRINT USING "              DAM CONCRETE                           ##.###
.##" + " m^3"; C2
1660 LPRINT USING "              SPILLWAY CONCRETE                      ##.###
.##" + " m^3"; C3
1670 LPRINT USING "              EARTH EXCAVATION                       ##.###
.##" + " m^3"; EEX
1680 LPRINT USING "              ROCK EXCAVATION                        ##.###
.##" + " m^3"; REX
1690 LPRINT USING "              ACCESS ROAD                         #.###.###
.##" + " km"; C7
1700 LPRINT USING "              FISHWAY                             #.###.###
.##" + " m"; C8: LPRINT
1710 LPRINT "      ECONOMIC FACTORS"
1720 LPRINT "      ----------------"
1730 LPRINT USING "              EQUIPMENT COST ADJUSTMENT FACTOR         ###
.##"; F1
1740 LPRINT USING "              FUEL FACTOR                              ###
.##"; F2
1750 LPRINT USING "              INTEREST RATE                            ###
.##"; I
1760 LPRINT USING "              OPERATION AND MAINTENANCE                ###
.##"; C9
1770 LPRINT USING "              REVENUE                                  ###
```

```
.##" + " mills/KWh"; M1
1780 LPRINT CHR$(12)
1790 LPRINT TAB(26); "SHYDRO-PC  VERSION 3.2  MARCH  1991": LPRINT : LPRINT
1800 LPRINT TAB(30); "       COST ESTIMATE      ": LPRINT
1810 LPRINT TAB(32); "   DATE : "; DATE$: LPRINT : LPRINT : LPRINT
1820 LPRINT "       WATER SHED : "; W$
1830 LPRINT "       ------------"
1840 LPRINT "       SITE NAME : "; S$
1850 LPRINT "       -----------"
1854 LPRINT "       FILE : "; F$
1855 LPRINT "       ------": LPRINT
1860 LPRINT USING "       INSTALLED CAPACITY :  ###.###" + " kW"; M * 1000
1870 LPRINT "       --------------------": LPRINT : LPRINT
1874 LPRINT USING "       LEAST COST ($C1986) See Appendix I-Section .14 $$###,###,###
.###"; ZZ1
1876 LPRINT "       --------------------": LPRINT : LPRINT
1880 LPRINT "       COST ESTIMATE"
1890 LPRINT "       -------------"
1900 IF M * 1000 <= 250 AND D <= 2.5 THEN DAM$ = "( A-FRAME )  ": N4 = 0: GOTO 1905
1901 GOTO 1910
1905 LPRINT USING "              DAM " + DAM$ + "                          $$###,###.
###"; E: GOTO 2100
1910 IF E <> N1 THEN 1940
1920 DAM$ = "(TIMBER CRIB)"
1930 GOTO 1990
1940 IF E <> N2 THEN 1970
1950 DAM$ = "(CONCRETE)   "
1960 GOTO 1990
1970 IF E <> N5 THEN 1990
1980 DAM$ = "(EARTHFILL)  "
1990 LPRINT
2000 IF E <> N1 THEN 2030
2010 LPRINT USING "              DAM " + DAM$ + "                          $$###,###.
###"; N1
2020 GOTO 2080
2030 IF E <> N2 THEN 2060
2040 LPRINT USING "              DAM " + DAM$ + "                          $$###,###.
###"; N2
2050 GOTO 2080
2060 IF E <> N5 THEN 2100
2070 LPRINT USING "              DAM " + DAM$ + "                          $$###,###.
###"; N3
2080 IF E <> N5 THEN N4 = 0: GOTO 2100
2090 LPRINT USING "              SPILLWAY                                   $$###,###
.###"; N4
2100 LPRINT USING "              UNWATERING                                 $$###,###
.###"; U1
2110 IF CL <= 0 THEN 2150
2120 LPRINT USING "              CONTROL STRUCTURE                          $$###,###
.###"; CTLSTR
2130 IF CL <= 0 THEN 2150
2140 LPRINT USING "              CANAL " + TYPE$ + "                      $$###,###,###";
 CCANAL
2150 LPRINT USING "              INTAKE                                     $$###,###
```

```
.###"; Z2
2160 LPRINT USING "              PENSTOCK " + P$ + "                    $$###,###.##
#"; PCOST
2170 LPRINT USING "              POWERHOUSE  -  CIVIL                      $$###,###
.###"; Z6
2180 LPRINT USING "                         -  EQUIPMENT SUPPLY            $$###,###
.###"; Z7
2190 LPRINT USING "                         -  EQUIPMENT ERECTION          $$###,###
.###"; Z8
2200 LPRINT USING "              TRANSMISSION LINE AND SUBSTATION          $$###,###
.###"; T2
2210 IF V1 < 1 THEN 2230
2220 LPRINT USING "              FISHWAY                                   $$###,###
.###"; V1
2230 LPRINT USING "              ACCESS ROAD                               $$###,###
.###"; Z9
2240 IF ADN < 1 THEN 2260
2250 LPRINT USING "              ADDITIONAL COST                           $$###,###
.###"; ADN
2260 LPRINT
2270 LPRINT USING "                      SUBTOTAL DIRECT COSTS             $$###,###
.###"; G - Y5 - Y6 - Z1
2280 LPRINT USING "                      CONTRACTOR OVERHEAD               $$###,###
.###"; Y5
2290 LPRINT USING "                      OWNER AND ENGINEERING             $$###,###
.###"; Y6
2300 LPRINT USING "                      INTEREST DURING CONSTRUCTION      $$###,###
.###"; Z1: LPRINT
2310 LPRINT USING "                      TOTAL PROJECT COST             $$###,###,###
.###"; G: LPRINT
2320 IF M < 5 THEN 2340
2330 LPRINT "       NOTE : SUBSTATION COST INCLUDED IN EQUIPMENT SUPPLY COST"
2340 LPRINT : LPRINT "       BENEFIT/COST ANALYSIS"
2350 LPRINT "       ---------------------": LPRINT
2360 LPRINT USING "              ANNUAL COST                            $$###,###,###
.###"; C
2370 LPRINT USING "              ANNUAL BENEFIT                         $$###,###,###
.###"; B
2380 LPRINT USING "              BENEFIT/COST RATIO                              ###
.###"; Y9
2385 LPRINT : LPRINT : LPRINT MESSAGE$
2390 LPRINT CHR$(12)
2395 GOSUB 10100
2400 RETURN
2410 REM ************************* FILE I/O SUBROUTINES ************************
2420 CLS
2430 GOSUB 6860
2440 REM
2450 HELP = 3
2460 LOCATE 10, 28: COLOR 0, 7: PRINT "---- FILE MANAGER ----";
2470 COLOR 7, 0
2480 LOCATE 12, 25: COLOR 0, 7: PRINT "F1": COLOR 7, 0: LOCATE 12, 27: PRINT " Save in
put to disk";
2490 LOCATE 14, 25: COLOR 0, 7: PRINT "F2": COLOR 7, 0: LOCATE 14, 27: PRINT " Recall
```

```
data from disk";
2495 LOCATE 16, 25: COLOR 0, 7: PRINT "F3": COLOR 7, 0: LOCATE 16, 27: PRINT " Delete
data files from disk";
2500 LOCATE 18, 25: COLOR 0, 7: PRINT "F4": COLOR 7, 0: LOCATE 18, 27: PRINT " Directo
ry listing of data files";
2510 LOCATE 20, 25: COLOR 0, 7: PRINT "F5": COLOR 7, 0: LOCATE 20, 27: PRINT " Return
to Main Menu";
2520 LOCATE 22, 25: COLOR 0, 7: PRINT "F10": COLOR 7, 0: LOCATE 22, 28: PRINT " Help";
2530 LOCATE 25, 30: PRINT " Enter Menu Selection";
2540 LOCATE 25, 52: INPUT ; CHOICE
2550 IF INT(CHOICE) <> CHOICE THEN GOTO 2590
2560 IF CHOICE = 10 THEN GOSUB 6550: GOTO 2410
2570 IF (CHOICE < 0) AND (CHOICE > 5) THEN GOTO 2590
2580 ON CHOICE GOTO 2600, 2720, 2831, 2840, 2860
2590 LOCATE 25, 15: PRINT "Invalid entry"; : GOSUB 7740: GOTO 2540
2600 LOCATE 25, 1: PRINT B$;
2610 LOCATE 25, 34: PRINT "Enter name of file to receive data";
2620 LOCATE 25, 69: INPUT ; F$: LOCATE 25, 1: PRINT B$;
2630 IF F$ = "" GOTO 2410
2640 OPEN "o", #2, F$ + ".SH2"
2650 FOR II = 1 TO 37
2660 IF II = 36 THEN PRINT #2, W$: GOTO 2690
2670 IF II = 37 THEN PRINT #2, S$: GOTO 2690
2680   PRINT #2, C(II)
2690 NEXT II
2700 CLOSE #2
2710 RETURN
2720 LOCATE 25, 1: PRINT B$;
2730 LOCATE 25, 22: PRINT "Enter name of file from which to retrieve data";
2740 LOCATE 25, 69: INPUT F$: IF F$ = "" THEN GOTO 2410
2750 LOCATE 25, 1: PRINT B$; : KODE = 1
2760 OPEN "i", #2, F$ + ".SH2"
2770 FOR I = 1 TO 37
2780 IF I = 36 THEN INPUT #2, W$: GOTO 2810
2790 IF I = 37 THEN INPUT #2, S$: GOTO 2810
2800   INPUT #2, C(I)
2810 NEXT I
2820 CLOSE #2
2830 RETURN
2831 LOCATE 25, 1: PRINT B$;
2832 LOCATE 25, 34: PRINT "Enter name of file to DELETE";
2833 LOCATE 25, 69: INPUT ; A$: LOCATE 25, 1: PRINT B$;
2834 IF A$ = "" GOTO 2410
2835 KILL A$ + ".SH2"
2836 GOTO 2410
2840 CLS : LOCATE 10, 1: FILES "*.SH2 ": GOSUB 7170
2850 GOTO 2410
2860 RETURN
2870 REM ***************************** EXIT SHYDRO-PC ********************************
2880 CLS
2890 LOCATE 13, 30: PRINT "ARE YOU SURE (YES/NO) ?"; : LOCATE 13, 54
2900 ANS$ = INKEY$: IF ANS$ = "" THEN GOTO 2900
2910 IF ANS$ = "Y" OR ANS$ = "y" THEN CLS : SYSTEM
2920 IF ANS$ = "N" OR ANS$ = "n" THEN RETURN
```

```
2930 BEEP: LOCATE 13, 16: PRINT "INVALID ENTRY"; : GOTO 2890
2940 REM ***************************** CLEAR ROUTINE ******************************
2950 CLS : LOCATE 13, 18: PRINT "ALL INPUT PARAMETERS WILL BE RESET TO ZERO";
2960 LOCATE 14, 30: PRINT "ARE YOU SURE (YES/NO)";
2970 ANS$ = INKEY$: IF ANS$ = "" THEN GOTO 2970
2980 IF ANS$ = "Y" OR ANS$ = "y" THEN FOR I = 1 TO 37: C(I) = 0: NEXT I: W$ = "": S$ =
 "": KODE = 0: RETURN
2990 IF ANS$ = "N" OR ANS$ = "n" THEN RETURN
3000 BEEP: LOCATE 14, 16: PRINT "INVALID ENTRY"; : GOTO 2970
3010 REM ********************* RESERVED FOR FUTURE USE ***************************
3020 RETURN
3030 REM ********************* FIRST TIME USER OF SHYDRO-PC **********************
3040 CLS
3050 I = 0
3060 OPEN "i", 1, "in.tro"
3070 IF EOF(1) THEN GOTO 3120
3080   I = I + 1: IF I = 24 THEN GOSUB 7130: I = 0: CLS  ELSE GOTO 3090
3090   LINE INPUT #1, A$
3100   PRINT A$
3110 GOTO 3070
3120 CLOSE #1
3130 GOSUB 7130
3140 RETURN
3150 REM ************************** COMPUTATIONAL UNIT ***************************
3160 IF KODE < 1 THEN CLS : LOCATE 12, 29: COLOR 0, 7: PRINT "  SITE DATA NOT INPUTTED
  "; : COLOR 7, 0: GOSUB 7130: RETURN
3170 KODE = 2
3180 CLS
3190 C1 = C(1): C2 = C(2): C3 = C(3): EEX = C(4): REX = C(5): C7 = C(6)
3200 C8 = C(7): I = C(8): C9 = C(9): M1 = C(10): F1 = C(11): F2 = C(12)
3210 S2 = C(13): F = C(14): Q2 = C(15): Q1 = C(16): TSUB = C(17): ADN = C(18) * 1000
3220 H = C(19): D = C(20): L = C(21): DD = C(22): CL = C(23): SS = C(24)
3230 DOB = C(25): P = C(26): PT = C(27): U = C(29): T = C(30): A = C(31)
3235 R1 = C(32): R2 = C(33): CTL = C(34): TWE = C(35)
3240 MESSAGE$ = ""
3260 REM ********************** CALCULATE DESIGN FLOW ***************************
3270 Q = C(28) * C(15)
3290 REM ********************** CALCULATE PLANT CAPACITY ************************
3300 M = .00814 * H * Q
3330 Z0 = 0    'COST TRANSMISSION LINE
3350 Z2 = 0    'INTAKE
3360 Z3 = 0    'PENSTOCK
3370 Z4 = 0    'PENSTOCK
3380 Z5 = 0    'PENSTOCK
3390 Z6 = 0    'POWER HOUSE CIVIL
3400 Z7 = 0    'EQUIP SUPPLY
3410 Z8 = 0    'EQUIP ERECTION
3420 Z9 = 0    'ACCESS ROAD
3430 N1 = 0    'TIMBER CRIB DAM
3440 N2 = 0    'CONCRETE DAM
3450 N3 = 0    'EARTHFILL DAM
3460 N4 = 0    'SPILLWAY
3470 N5 = 0    'DAM&SPILLWAY
3480 E = 0      'MINIMUM DAM COST
```

```
3490 Y3 = 0   'PARTIAL TOTAL
3500 Y4 = 0   'PARTIAL TOTAL
3510 Y5 = 0   'CONTRACTOR COST
3520 Y6 = 0   'ENGINEER COST
3530 Y7 = 0
3540 V1 = 0   'FISHWAY
3550 B = 0
3560 C = 0
3570 V9 = 0
3590 REM ****** GOTO CANAL SUBROUTINE IF CANAL LENGTH IS GREATER THAN 0 ******
3600 IF CL > 0 THEN GOSUB 7890: GOTO 3625
3610 CCANAL = 0: CTLSTR = 0
3625 REM ---------- CALCULATION SUBROUTINE ----------
3630 REM ********** CALCULATE LEAST COST **********
3640 ZZ1 = INT((8.3 * 10 ^ 6 * (M / H ^ .3) ^ .82) / 100) * 100
3650 IF (M * 1000 / (H ^ .3)) < 338 THEN ZZ1 = INT((2350 * ((M * 1000 / (H ^ .3)) ^ 1.
25)) / 100) * 100
3680 REM ********** CALCULATE COST OF INTAKE **********
3700 Z2 = INT((U * 1.12 * (190 * EEX + 37.5 * C3) * (Q / U) ^ .9) / 10) * 10
3720 REM ********** CALCULATE THE COST OF THE PENSTOCK **********
3740 REM ********** FIRST CALC THE ECONOMIC DIAMETER P1 **********
3750 P1 = F2 ^ .143 * 1.26 * (Q / U) ^ .43 / H ^ .14
3770 REM ********** NEXT CALC THE PENSTOCK THICKNESS   P2 **********
3780 P2 = 7.5 + P1 / .8
3790 TMAX = .0405 * H * P1 + 2.5
3800 TAV = (TMAX ^ 2 + P2 ^ 2) / (2 * TMAX)
3810 IF P2 > TMAX THEN GOTO 3830
3820 P2 = TAV
3830 PF = INT((P * U * (F1 * 460 * P1 + 1.25 * EEX * (P1 + .6) * (.5 * P1 + .5) - 2 *
EEX * (.5 * P1) * (.5 * P1))) / 10) * 10
3840 IF PT = 0 THEN PP = INT((P * U * (F1 * 800 * P1 * P1 + .65 * EEX)) / 10) * 10 ELS
E PP = INT((P * U * F1 * 313 * (P1 + .03) + P * (.5 + .5 * U) * (1.2 * EEX + .3 * REX)
) / 10) * 10
3850 IF PT = 0 THEN 3855
3852 PS = INT((P * U * F1 * .082 * TAV * (P1 * 1000 + TAV) + P * U * 9.000001E-02 * C3
 * PI ^ 2 + .6 * (EEX + REX) * PI ^ 2 * P * (.5 + .5 * U)) / 10) * 10
3854 GOTO 3860
3855 PS = INT((P * U * (F1 * 109 * P1 * P2 + 1.25 * EEX * P1 * (P1 + 1.5) + .65 * EEX
* (P1 + 1.5) * (P1 + 1.5))) / 10) * 10
3860 IF PT = 1 THEN GOSUB 6510: GOTO 3880
3870 GOSUB 6160
3880 REM ********** CALC COST PENSTOCK SUPPLY **********
3890 Z3 = 3.2 * P * 24.8 * P1 * P2 * U
3900 REM ********** CALC COST PENSTOCK ERECTION **********
3910 Z4 = 1.2 * P * 24.8 * P1 * P2 * U
3920 REM ********** CALC COST EXCAVATION & BACKFILL **********
3930 Z5 = (U) * (EEX * P * (P1 * (P1 + 1.5) + .5 * (P1 + 1.5) ^ 2))
3940 Y8 = Z3 + Z4 + Z5
3950 REM ********** CALCULATE POWERHOUSE COST WHERE Z6 = CIVIL COST **********
3960 REM                                          Z7 = SUPPLY COST **********
3970 REM                                          Z8 = ERECTION COST *******
3980 IF P / H <= 8 THEN FACTOR = 1 ELSE FACTOR = 1.12
3985 F3 = C3 / 500
3990 IF M >= 5 THEN 4050
```

```
4000 ZTOT = 5.55 * 10 ^ 6 * M ^ .7 / H ^ .35
4010 Z6 = INT((F3 * .17 * ZTOT) / 10) * 10
4020 Z7 = INT((F1 * .35 * ZTOT * FACTOR) / 10) * 10
4030 Z8 = INT((.3 * Z7) / 10) * 10
4040 GOTO 4100
4050 J = .32 * M ^ .058
4060 ZTOT = (4 * 10 ^ 6 * M ^ .92) / H ^ J
4070 Z6 = INT((F3 * .17 * ZTOT) / 10) * 10
4080 Z7 = INT((F1 * .34 * ZTOT * FACTOR) / 10) * 10
4090 Z8 = INT((.3 * Z7) / 10) * 10
4091 IF M * 1000 <= 250 THEN ZTOT = 1.01 * 10 ^ 6 * M ^ .6 / H ^ .25: GOTO 4093
4092 GOTO 4100
4093 Z6 = INT((F3 * .3 * ZTOT) / 10) * 10
4094 Z7 = INT((F1 * .5 * ZTOT * FACTOR) / 10) * 10
4095 Z8 = INT((.4 * Z7) / 10) * 10
4100 REM ********** CALCULATE COST OF ACCESS ROAD **********
4130 Z9 = INT((1.27 * C7 * (A ^ .85)) / 10) * 10
4140 REM ********** CALCULATE COST OF UNWATERING **********
4160 U1 = INT((100 * 1.5 * EEX * F / 2) / 10) * 10
4165 IF M * 1000 <= 250 AND D <= 2.5 THEN U1 = INT((.15 * (F1 * L * D * 200)) / 10) *
10
4180 REM ********** CALCULATE COST OF TRANSMISSION LINE **********
4190 IF M >= 1 THEN 4220
4200 Z0 = (.5 * F1 + .5 * EEX / 10) * 38000! * T
4210 GOTO 4230
4220 Z0 = (.5 * F1 + .5 * EEX / 10) * 8800 * (4.28 + (M - 1) ^ .5) * M ^ .1 * T ^ .9
4230 REM ********** CALCULATE SUBSTATION COST **********
4240 IF M >= 5 THEN 4300
4250 S3 = F1 * 1350 * (M * 1000) ^ .6
4270 REM ********** CALCULATE TRANSMISSION PLUS SUBSTATION COST **********
4280 T2 = INT((S3 + Z0) / 10) * 10
4290 GOTO 4310
4300 T2 = INT((Z0) / 10) * 10
4310 REM ********** CALCULATE COST OF FISHWAY **********
4330 V1 = INT((C8 * D * S2) / 10) * 10
4340 REM ********** CALCULATE EARTHFILL DAM VOLUME **********
4350 V9 = 4.4 * L * (D + 4) + 1.52 * L * (D + 4) * (D + 4)
4360 REM ********** CALCULATE EARTHFILL DAM COST **********
4370 IF V9 > 15000 THEN 4400
4380 N3 = INT((17.9 * 1.5 * EEX * (V9 ^ .7)) / 10) * 10
4390 GOTO 4410
4400 N3 = INT((2.6 * 1.5 * EEX * (V9 ^ .9)) / 10) * 10
4410 REM ********** CALCULATE COST OF DAM **********
4420  IF D > 8 THEN 4540
4430 N1 = INT((1.4 * C1 * (L * .55 * (1.2 * D + .625 * D ^ 2)) ^ .95) / 10) * 10
4440 N2 = INT((2 * C2 * (.55 * L * (D + .375 * D ^ 2)) ^ .9) / 10) * 10
4450 IF N2 > N1 THEN 4480
4460 E = INT((N2) / 10) * 10
4470 GOTO 4490
4480 E = INT((N1) /*10) * 10
4490 N4 = INT((C3 * (F * 3 * (D + 4)) ^ .78) / 10) * 10
4500 N5 = INT((N3 + N4) / 10) * 10
4510 IF N5 > E THEN 4530
4520 E = INT((N5) / 10) * 10
```

```
4530 GOTO 4660
4540 IF D > 16 THEN 4630
4550 N2 = INT((2 * C2 * (.55 * L * (D + .375 * D ^ 2)) ^ .9) / 10) * 10
4560 N4 = INT((C3 * (F * 3 * (D + 4)) ^ .78) / 10) * 10
4570 N5 = INT((N3 + N4) / 10) * 10
4580 IF N2 > N5 THEN 4610
4590 E = INT((N2) / 10) * 10
4600 GOTO 4620
4610 E = INT((N5) / 10) * 10
4620 GOTO 4660
4630 N4 = INT((C3 * (F * 3 * (D + 4)) ^ .78) / 10) * 10
4640 N5 = INT((N3 + N4) / 10) * 10
4650 E = INT((N5) / 10) * 10
4660 IF M * 1000 <= 250 AND D <= 2.5 THEN E = INT((F1 * L * D * 200) / 10) * 10
4670 REM ********** CALCULATE CONTRACTORS OVERHEAD COST **********
4680 Y3 = .1 * (E + Z2 + Z4 + Z5 + Z6 + Z9 + Z8 + V1 + U1 + CCANAL + CTLSTR + ADN) ^ .
89
4690 K1 = .005 * R1 + .001 * R2
4700 IF K1 > .4 THEN 4730
4710 Y4 = INT((K1 * (E + Z2 + Z5 + Z6 + Z9 + V1 + U1 + CCANAL + CTLSTR + ADN)) / 10) *
 10
4720 GOTO 4740
4730 Y4 = INT((.4 * (E + Z2 + Z6 + Z9 + Z5 + V1 + U1 + CCANAL + CTLSTR + ADN)) / 10) *
 10
4740 Y5 = Y4
4760 REM ********** CALCULATE ENGINEERING & OWNERS COST **********
4770 ZZZ = Z2 + Z3 + Z4 + Z5 + Z6 + Z7 + Z8
4780 Y6 = INT((.6 * (E + ZZZ + Z9 + Z0 + Y5 + V1 + U1 + CCANAL + CTLSTR + ADN) ^ .89)
/ 10) * 10
4800 G9 = Z9 + E + ZZZ + Z0 + Y5 + Y6 + V1 + U1 + CCANAL + CTLSTR + ADN
4810 REM ********** CALCULATE INTEREST DURING CONSTRUCTION **********
4820 W = (G9 / 2) * .06
4830 IF M >= 5 THEN 4860
4840 Z1 = INT((W * .172 * (M * 1000) ^ .25) / 10) * 10
4850 GOTO 4880
4860 Z1 = INT((W * .0134 * (M * 1000) ^ .55) / 10) * 10
4870 REM CALCULATE GRAND TOTAL
4880 ZZZZ = Z6 + Z7 + Z8 + Z9
4890 G = ZZZZ + E + Z2 + PCOST + T2 + Y5 + Y6 + V1 + Z1 + U1 + CCANAL + CTLSTR + ADN
4910 REM ********** CALCULATE COST PER KW **********
4930 G1 = G / (1000 * M)
4940 REM ********** CALCULATE CAPACITY FACTOR **********
4950 Q3 = Q1 / Q2
4960 REM ********** CALCULATE ANNUAL COST **********
4970 C = INT((G * (I + C9) / 100) / 10) * 10
4980 REM ********** CALCULATE ANNUAL BENEFIT **********
4990 B = INT(((Q1 / Q2) * M * 8760 * M1) / 10) * 10
5000 REM ********** CALCULATE BENEFIT/COST RATIO **********
5010 Y9 = B / C
5015 GOSUB 9800
5020 CLS
5030 REM LOCATE 1, 20: COLOR 0, 7: PRINT " WATER SHED : ": COLOR 7, 0: LOCATE 1, 35: P
RINT W$
5040 REM LOCATE 2, 20: COLOR 0, 7: PRINT " SITE NAME  : ": COLOR 7, 0: LOCATE 2, 35: P
```

```
KINT S$
5050 IF T <= 10 * H THEN 5080
5060 PRINT "NOTE - TRANSMISSION LINE LENGTH EXCEEDS 10*HW"
5070 GOTO 5090
5080 PRINT
5090 IF P >= 20 * H THEN 5100 ELSE 5110
5100 PRINT "NOTE - PENSTOCK LENGTH EXCEEDS 20 x HEAD (SURGE TANK MAY BE REQUIRED)": GO
TO 5130
5110 IF P >= 8 * H THEN 5120 ELSE 5130
5120 PRINT "NOTE - PENSTOCK LENGTH EXCEEDS 8 x HEAD (PRESSURE RELIEF VALVE ADDED)"
5130 LOCATE 3, 1: COLOR 0, 7: PRINT " SITE DATA          ": COLOR 7, 0
5140 PRINT USING "        INSTALLED CAPACITY                    ##,###,###" + " kW"; M
* 1000
5150 PRINT USING "        NUMBER OF UNITS                          ##"; U
5160 PRINT USING "        GROSS HEAD                            ##.###.##" + " m"; H
5164 PRINT USING "        TAILWATER ELEVATION                   ###.###.##" + " m"; TWE
5166 PRINT USING "        TURBINE SUBMERGENCE                   ###.###.##" + " m"; TSU
B
5170 PRINT USING "        AVERAGE FLOW                          ##.###.###" + " m^3/s";
 C(28)
5180 PRINT USING "        FLOOD FLOW                              ###.###" + " m^3/s";
 F
5190 PRINT USING "        PLANT DESIGN FLOW RATIO                 ####.##"; Q2
5200 PRINT USING "        USEABLE FLOW RATIO                      ####.##"; Q1
5210 PRINT USING "        HEIGHT OF DAM                          #.###.##" + " m"; D
5220 PRINT USING "        LENGTH OF DAM                         ###.###.##" + " m"; L
5230 IF CL <= 0 THEN 5280
5240 PRINT USING "        DRAWDOWN (F.S.L. - L.S.L.)              ###.##" + " m"; DD
5250 PRINT USING "        CANAL LENGTH                          ##.###.###" + " m"; CL
5260 PRINT USING "        CANAL MEAN TRANSVERSE SLOPE             ####.##"; SS
5270 PRINT USING "        CANAL DEPTH OF OVER BURDEN               ###.##" + " m"; DOB
5280 IF PT = 1 THEN PT$ = "(SURFACE)" ELSE PT$ = "(BURIED) "
5290 PRINT USING "        PENSTOCK LENGTH " + PT$ + "           #,###,###.##" + " m"; P
5310 PRINT USING "        TRANSMISSION LINE LENGTH               ##.###.##" + " km"; T
5320 PRINT USING "        ACCESS ROAD LENGTH                     ##.###.##" + " km"; A
5330 PRINT USING "        DISTANCE TO TOWN                       ##.###.##" + " km"; R1
5340 PRINT USING "        DISTANCE TO CONCRETE PLANT             ##.###.##" + " km"; R2
5350 GOSUB 7200
5360 CLS
5370 LOCATE 1, 30: COLOR 0, 7: PRINT "     UNIT COST DATA       ": COLOR 7, 0: PRINT
5380 PRINT "       WATER SHED :          "; W$
5390 PRINT "       SITE NAME  :          "; S$
5400 PRINT USING "       INSTALLED CAPACITY :###,###" + " kW"; M * 1000: PRINT
5410 COLOR 0, 7: PRINT " UNIT COST DATA       ": COLOR 7, 0
5420 PRINT
5430 PRINT USING "                TIMBER CRIB WORK                    ##,###.##" + "
 m^3"; C1
5440 PRINT USING "                DAM CONCRETE                        ##,###.##" + "
 m^3"; C2
5450 PRINT USING "                SPILLWAY CONCRETE                   ##,###.##" + "
 m^3"; C3
5460 PRINT USING "                EARTH EXCAVATION                    ##,###.##" + "
 m^3"; EEX
5470 PRINT USING "                ROCK EXCAVATION                     ##,###.##" + "
```

```
 m^3"; REX
5480 PRINT USING "                ACCESS ROAD                          #,###,###.##" + "
 km"; C7
5490 PRINT USING "                FISHWAY                              #,###,###.##" + "
 m"; C8
5500 PRINT : COLOR 0, 7: PRINT " ECONOMIC FACTORS     ": COLOR 7, 0: PRINT
5510 PRINT USING "                EQUIPMENT COST ADJUSTMENT FACTOR          ###.##"; F1
5520 PRINT USING "                FUEL FACTOR                               ###.##"; F2
5530 PRINT USING "                INTEREST RATE                             ###.##"; I
5540 PRINT USING "                OPERATION AND MAINTENANCE                 ###.##"; C9
5550 PRINT USING "                REVENUE                                   ###.##" + "
 mills/KWh"; M1
5560 GOSUB 7230: PRINT A$: IF A$ = "b" OR A$ = "B" THEN GOTO 5020 ELSE CLS
5570 CLS : LOCATE 1, 30: COLOR 0, 7: PRINT "     COST ESTIMATE       ": COLOR 7, 0: PR
INT
5580 PRINT "       WATER SHED :           "; W$
5590 PRINT "       SITE NAME  :           "; S$
5600 PRINT USING "       INSTALLED CAPACITY : ###,###" + " kW"; M * 1000: PRINT
5610 COLOR 0, 7: PRINT " COST ESTIMATE       ": COLOR 7, 0
5620 PRINT
5630 IF M * 1000 <= 250 AND D <= 2.5 THEN DAM$ = "( A-FRAME )  ": N4 = 0: GOTO 5632
5631 GOTO 5640
5632 PRINT USING "              DAM " + DAM$ + "                                $$###,###.
###"; E: GOTO 5830
5640 IF E <> N1 THEN 5670
5650 DAM$ = "(TIMBER CRIB)"
5660 GOTO 5720
5670 IF E <> N2 THEN 5700
5680 DAM$ = "(CONCRETE)   "
5690 GOTO 5720
5700 IF E <> N5 THEN 5720
5710 DAM$ = "(EARTHFILL)  "
5720 IF E <> N1 THEN 5760
5740 PRINT USING "              DAM " + DAM$ + "                                $$###,###.
###"; N1
5750 GOTO 5810
5760 IF E <> N2 THEN 5790
5770 PRINT USING "              DAM " + DAM$ + "                                $$###,###.
###"; N2
5780 GOTO 5810
5790 IF E <> N5 THEN 5830
5800 PRINT USING "              DAM " + DAM$ + "                                $$###,###.
###"; N3
5810 IF E <> N5 THEN N4 = 0: GOTO 5830
5820 PRINT USING "              SPILLWAY                                        $$###.###
.###"; N4
5830 PRINT USING "              UNWATERING                                      $$###.###
.###"; U1
5840 IF CL <= 0 THEN 5860
5850 PRINT USING "              CONTROL STRUCTURE                               $$###.###
.###"; CTLSTR
5860 IF CL <= 0 THEN 5880
5870 PRINT USING "              CANAL " + TYPE$ + "                          $$###,###,###";
 CCANAL
```

```
5880 PRINT USING "              INTAKE                                    $$###,###
,###"; Z2
5890 PRINT USING "              PENSTOCK " + P$ + "                      $$###,###,##
#"; PCOST
5900 PRINT USING "              POWERHOUSE  -  CIVIL                      $$###,###
,###"; Z6
5910 PRINT USING "                          -  EQUIPMENT SUPPLY           $$###,###
,###"; Z7
5920 PRINT USING "                          -  EQUIPMENT ERECTION         $$###,###
,###"; Z8
5930 PRINT USING "              TRANSMISSION LINE AND SUBSTATION          $$###,###
,###"; T2
5940 IF V1 < 1 THEN 5960
5950 PRINT USING "              FISHWAY                                   $$###,###
,###"; V1
5960 PRINT USING "              ACCESS ROAD                               $$###,###
,###"; Z9
5970 IF ADN < 1 THEN 5980 ELSE PRINT USING "              ADDITIONAL COST
              $$###,###,###"; ADN
5980 GOSUB 7230: PRINT A$: IF A$ = "b" OR A$ = "B" THEN GOTO 5360 ELSE CLS
5990 LOCATE 1, 30: COLOR 0, 7: PRINT "     SUMMARY SHEET       ": COLOR 7, 0: PRINT
6000 PRINT "       WATER SHED :          "; W$
6010 PRINT "       SITE NAME  :          "; S$
6020 PRINT USING "       INSTALLED CAPACITY : ###,###" + " kW"; M * 1000: PRINT
6025 PRINT USING "       LEAST COST ($C1986)                              $$###,###,###
,###"; ZZ1: PRINT
6030 COLOR 0, 7: PRINT " COST SUMMARY        ": COLOR 7, 0: PRINT
6040 PRINT USING "                        SUBTOTAL DIRECT COSTS           $$###,###
,###"; G - Y5 - Y6 - Z1
6050 PRINT USING "                        CONTRACTOR OVERHEAD             $$###,###
,###"; Y5
6060 PRINT USING "                        OWNER AND ENGINEERING           $$###,###
,###"; Y6
6070 PRINT USING "                        INTEREST DURING CONSTRUCTION    $$###,###
,###"; Z1
6080 PRINT USING "                        TOTAL PROJECT COST              $$###,###,###
,###"; G: PRINT
6090 IF M < 5 THEN 6110
6100 PRINT "NOTE : SUBSTATION COST INCLUDED IN EQUIPMENT SUPPLY COST"
6110 PRINT : COLOR 0, 7: PRINT " BENEFIT/COST ANALYSIS      ": COLOR 7, 0: PRINT
6120 PRINT USING "                        ANNUAL COST                     $$###,###,###
,###"; C
6130 PRINT USING "                        ANNUAL BENEFIT                  $$###,###,###
,###"; B
6140 PRINT USING "                        BENEFIT/COST RATIO                        ###
.###"; Y9
6150 GOSUB 7230: PRINT A$: IF A$ = "b" OR A$ = "B" THEN GOTO 5570 ELSE RETURN
6155 REM ********************* PENSTOCK SELECTION ROUTINE ************************
6160 IF H > 60 THEN P$ = "(STEEL)      ": PCOST = PS: RETURN
6170 IF P1 < .3 THEN P$ = "(POLYETHLENE)": PCOST = PP: RETURN
6180 IF P1 > 2.5 THEN P$ = "(STEEL)      ": PCOST = PS: RETURN
6190 PKODE = 0
6200 IF P1 < 1! THEN PKODE = PKODE + 1
6210 IF P1 > .5 AND P1 < 2.5 THEN PKODE = PKODE + 2
```

```
6220 IF P1 > .3 THEN PKODE = PKODE + 4
6230 IF PKODE <> 7 THEN GOTO 6280
6240   PCOST = PP: P$ = "(POLYETHYLENE)"
6250   IF PS < PCOST THEN PCOST = PS: P$ = "(STEEL)      "
6260   IF PF < PCOST THEN PCOST = PF: P$ = "(FIBERGLASS) "
6270 RETURN
6280 IF PKODE <> 1 THEN GOTO 6320
6290   PCOST = PP
6300   P$ = "(POLYETHYLENE)"
6310 RETURN
6320 IF PKODE <> 2 THEN GOTO 6360
6330   PCOST = PF
6340   P$ = "(FIBERGLASS) "
6350 RETURN
6360 IF PKODE <> 4 THEN GOTO 6400
6370   PCOST = PS
6380   P$ = "(STEEL)      "
6390 RETURN
6400 IF PKODE <> 3 THEN GOTO 6440
6410   PCOST = PP: P$ = "(POLYETHYLENE)"
6420   IF PF < PCOST THEN PCOST = PF: P$ = "(FIBERGLASS) "
6430 RETURN
6440 IF PKODE <> 5 THEN GOTO 6480
6450   PCOST = PP: P$ = "(POLYETHYLENE)"
6460   IF PS < PCOST THEN PCOST = PS: P$ = "(STEEL)      "
6470 RETURN
6480 PCOST = PF: P$ = "(FIBERGLASS) "
6490 IF PS < PCOST THEN PCOST = PS: P$ = "(STEEL)      "
6500 RETURN
6510 IF P1 > 1.1 OR H > 122 - P1 * 77 THEN P$ = "(STEEL)      ": PCOST = PS: RETURN
6520 P$ = "(POLYETHLENE)": PCOST = PP
6530 IF PS < PCOST THEN P$ = "(STEEL)      ": PCOST = PS
6540 RETURN
6550 REM ************************** HELP SUBROUTINE ****************************
6560 CLS
6570 ON HELP GOTO 6580, 6670, 6820
6580 PRINT
6585 PRINT : PRINT : LOCATE 5, 28: COLOR 0, 7: PRINT "   HELP  SCREEN   ": COLOR 7, 0:
 PRINT : PRINT
6590 PRINT "  Select an integer number between 1 and 10 (inclusive) or"
6600 PRINT "  the function key F? where ? is the number of your choice"
6610 PRINT
6620 PRINT "  for example: by pressing either the key marked F1 or"
6630 PRINT "               a 1 followed by the return key you have"
6640 PRINT "               selected the 'Input data from keyboard' option";
6650 GOSUB 7130
6660 RETURN
6670 PRINT : PRINT : LOCATE 5, 28: COLOR 0, 7: PRINT "   HELP  SCREEN   ": COLOR 7, 0:
 PRINT : PRINT
6675 PRINT " By entering a string of commands the displayed parameters can be"
6680 PRINT "changed. The command language is as follows :"
6690 PRINT " "
6700 PRINT "  1-5          :  changes the parameters 1 to 5 inclusive"
6710 PRINT "  1,5,7        :  changes the parameters 1 then 5 then 7"
```

```
6720 PRINT "  1-5,7,9-11  :  changes the parameters 1 to 5 followed by 7"
6730 PRINT "                 and parameters 9 to 11"
6740 PRINT "  S           :  changes all the Site parameters"
6750 PRINT "  F           :  Indicates you have Finished changing the parameters"
6760 PRINT "                 and returns you to main menu"
6770 PRINT "  R           :  Runs the program on the displayed data parameters"
6780 PRINT "  D           :  re-displays input menu if an error has occured"
6790 PRINT "  Q           :  Exit from SHYDRO-PC and return to DOS";
6800 GOSUB 7170
6810 RETURN
6820 PRINT : PRINT : LOCATE 5, 28: COLOR 0, 7: PRINT "   HELP  SCREEN   ": COLOR 7, 0:
 PRINT : PRINT
6821 PRINT "  Select an integer number between 1 and 10 (inclusive) or"
6822 PRINT "  the function key F? where ? is the number of your choice"
6823 PRINT
6824 PRINT "  for example: by pressing either the key marked F1 or"
6825 PRINT "               a 1 followed by the return key you have"
6826 PRINT "               selected the 'Input data from keyboard' option";
6830 GOSUB 7170
6840 RETURN
6850 GOSUB 7130
6860 REM ************************** MAIN MENU **********************************
6870 CLS
6880 LOCATE 1, 38: PRINT "SHYDRO";
6890 LOCATE 2, 28: PRINT "( VER 3.2, March 1991 )";
6900 RETURN
6910 LOCATE 5, 26: PRINT "SHAWMONT NEWFOUNDLAND LIMITED";
6920 LOCATE 6, 34: PRINT "P.O. BOX 9600";
6930 LOCATE 7, 28: PRINT "St. JOHN'S, NEWFOUNDLAND";
6940 LOCATE 8, 37: PRINT "A1A 3C1";
6950 LOCATE 9, 28: PRINT "TELEPHONE (709) 754-0250";
6960 LOCATE 12, 30: COLOR 0, 7: PRINT "----- MAIN MENU -----";
6970 COLOR 7, 0
6980 LOCATE 14, 5: COLOR 0, 7: PRINT "F1": COLOR 7, 0: LOCATE 14, 7: PRINT " Examine/C
hange input parameters";
6990 LOCATE 16, 5: COLOR 0, 7: PRINT "F2": COLOR 7, 0: LOCATE 16, 7: PRINT " Intialize
 default cost parameters";
7000 LOCATE 18, 5: COLOR 0, 7: PRINT "F3": COLOR 7, 0: LOCATE 18, 7: PRINT " Send resu
lts to printer";
7010 LOCATE 20, 5: COLOR 0, 7: PRINT "F4": COLOR 7, 0: LOCATE 20, 7: PRINT " Write/Ret
rieve data to/from disk";
7020 LOCATE 22, 5: COLOR 0, 7: PRINT "F5": COLOR 7, 0: LOCATE 22, 7: PRINT " Exit prog
ram and return to DOS";
7030 LOCATE 14, 44: COLOR 0, 7: PRINT "F6": COLOR 7, 0: LOCATE 14, 46: PRINT " Reset a
ll input parameters to zero";
7040 LOCATE 16, 44: COLOR 0, 7: PRINT "F7": COLOR 7, 0: LOCATE 16, 46: PRINT " This ke
y reserved (future updates)";
7050 LOCATE 18, 44: COLOR 0, 7: PRINT "F8": COLOR 7, 0: LOCATE 18, 46: PRINT " New use
r of SHYDRO";
7060 LOCATE 20, 44: COLOR 0, 7: PRINT "F9": COLOR 7, 0: LOCATE 20, 46: PRINT " RUN";
7070 LOCATE 22, 43: COLOR 0, 7: PRINT "F10": COLOR 7, 0: LOCATE 22, 46: PRINT " HELP <
press key marked F10>";
7080 LOCATE 25, 30: INPUT "ENTER MENU SELECTION ", CHOICE
7090 IF INT(CHOICE) <> CHOICE THEN GOTO 7110
```

```
7100 IF (CHOICE >= 1) AND (CHOICE <= 10) THEN RETURN ELSE GOTO 7110
7110 LOCATE 25, 15: BEEP: PRINT "INVALID ENTRY"; : GOTO 7080
7120 RETURN
7130 REM ************************** BOTTOM LINE PROMPTS ************************
7140 LOCATE 25, 1: PRINT B$; : LOCATE 25, 44: PRINT "Press any key to return to main m
enu";
7150 A$ = INKEY$: IF A$ = "" THEN GOTO 7150
7160 LOCATE 25, 1: PRINT B$; : RETURN
7170 LOCATE 25, 1: PRINT B$; : LOCATE 25, 44: PRINT "Press any key to return to menu";
7180 A$ = INKEY$: IF A$ = "" THEN GOTO 7180
7190 LOCATE 25, 1: PRINT B$; : RETURN
7200 LOCATE 25, 1: PRINT B$; : LOCATE 25, 44: PRINT "Press any key to continue";
7210 A$ = INKEY$: IF A$ = "" THEN GOTO 7210
7220 LOCATE 25, 1: PRINT B$; : RETURN
7230 LOCATE 25, 1: PRINT B$; : LOCATE 25, 22: PRINT "Press any key to continue or B to
 display previous screen ";
7240 A$ = INKEY$: IF A$ = "" THEN GOTO 7240
7250 LOCATE 25, 1: PRINT B$; : RETURN
7260 BEEP: LOCATE 25, 1: PRINT B$; : LOCATE 25, 22: PRINT "Error in command string ent
ered suspect value "; NUM; " or "; SNUM
7270 A$ = INKEY$: IF A$ = "" THEN GOTO 7270
7280 LOCATE 25, 1: PRINT B$; : RETURN
7290 REM ************************** PARSER FOR INPUT ***************************
7300 KEY 10, "H" + CHR$(13)
7320 HELP = 2
7330 LOCATE 24, 1
7340 PRINT "PRESS <F10> FOR HELP ";
7350 LOCATE 25, 1: PRINT B$; : LOCATE 25, 1
7360 COLOR 0, 7: LINE INPUT ; " ENTER COMMAND STRING ? "; A$: LOCATE 25, 23: COLOR 7,
0
7380 IF (A$ = "D") OR (A$ = "d") THEN RETURN 860
7390 IF (A$ = "H") OR (A$ = "h") THEN GOSUB 6550: RETURN 860
7400 IF (A$ = "R") OR (A$ = "r") THEN GOTO 3150: RETURN
7410 IF (A$ = "F") OR (A$ = "f") THEN RETURN
7420 IF (A$ = "S") OR (A$ = "s") THEN A$ = "19-35,13-18,36,37"
7430 IF (A$ = "Q") OR (A$ = "q") THEN GOSUB 2870: RETURN 860
7440 A$ = A$ + " "
7450 FOR I = 1 TO LEN(A$)
7460  IF MID$(A$, I, 1) = "-" THEN MID$(A$, I, 1) = "t"
7470 NEXT I
7480 NUM = VAL(A$)
7490 IF NUM = 0 THEN GOTO 7300
7500 IF (INT(NUM) <> NUM) OR (NUM < 1) OR (NUM > 37) THEN GOSUB 7260: GOTO 7300
7510 KODE = 1
7520 K$ = STR$(NUM)
7530 A$ = RIGHT$(A$, LEN(A$) - LEN(K$) + 1)
7540 M$ = MID$(A$, 1, 1)
7550 A$ = RIGHT$(A$, LEN(A$) - 1)
7560 IF M$ = " " THEN GOTO 7580
7570 IF M$ <> "," THEN GOTO 7620
7580  I = NUM: LOCATE 25, 1: PRINT B$; : LOCATE 25, 1: PRINT C$(I); " "; : LOCATE 25,
40: IF I < 36 THEN INPUT ; C(I): GOSUB 7760: GOTO 7480
7590 IF NUM = 36 THEN INPUT ; W$
7600 IF NUM = 37 THEN INPUT ; S$
```

```
7610  GOSUB 7760
7620 IF (M$ = "T") OR (M$ = "t") THEN GOTO 7630 ELSE GOTO 7480
7630  SNUM = VAL(A$)
7640 IF (INT(SNUM) <> SNUM) OR (SNUM < 1) OR (SNUM > 37) THEN GOSUB 7260: GOTO 7300
7650 K$ = STR$(SNUM)
7660 FOR I = NUM TO SNUM
7670   LOCATE 25, 1: PRINT B$; : LOCATE 25, 1: PRINT C$(I); : LOCATE 25, 40: IF I < 36
 THEN INPUT ; C(I)
7680 IF I = 36 THEN INPUT ; W$
7690 IF I = 37 THEN INPUT ; S$
7700 GOSUB 7760
7710 NEXT I
7720 A$ = RIGHT$(A$, LEN(A$) - LEN(K$))
7730 GOTO 7480
7740 BEEP
7750 RETURN
7760 REM ****************** UPDATE INPUT PARAMETERS AS NEEDED ******************
7770 IF I < 19 THEN LOCATE I + 4, 1 ELSE LOCATE I - 14, 45
7780   IF I = 36 THEN LOCATE 22, 45: PRINT USING "##) \           \\          \
"; I; C$(I); W$: RETURN
7790   IF I = 37 THEN LOCATE 23, 45: PRINT USING "##) \           \\          \
"; I; C$(I); S$; : RETURN
7800 IF I < 19 THEN PRINT USING "##) \                          \######.##"; I; C$(I);
 C(I); : RETURN
7810 PRINT USING "##) \                        \####.##"; I; C$(I); C(I); : RETURN
7820 CLS : LOCATE 13, 40
7830 IF ERR = 25 THEN PRINT "CHECK PRINTER"; : GOSUB 7200: GOTO 7880
7840 IF ERR = 53 THEN PRINT "FILE NOT FOUND"; : GOSUB 7200: CLS : RESUME 2720
7850 IF ERR = 27 THEN PRINT "CHECK PRINTER FOR PAPER"; : GOSUB 7200: RESUME
7860 IF ERR = 67 THEN PRINT "TOO MANY FILES ON DISKETTE TRY ANOTHER ONE"; : LOCATE 14,
 40: PRINT "  OR FILE NAME IS INCORRECT (NO PUNCUATION MARKS ALLOWED)": GOSUB 7200: RE
SUME 2410
7870 IF ERR = 71 THEN PRINT "CHECK DISK DRIVE "; : GOSUB 7200: RESUME
7880 RESUME
7890 REM ********** THIS PART OF THE PROGRAM IS USED TO CALCULATE **************
7910 REM ******* AN OPTIMUM CANAL BASED ON GIVEN CANAL PARAMETERS *************
7940 CCANAL = 0: CTLSTR = 0: AREACUT = 0: AREAROCK = 0: AREAFILL = 0: HEIGHTW = 0: DEL
TA = 0: BOTTOMW = 0
7950 FLOWA = Q / .6
7960 IF CTL > 0 THEN FREEB = 1.5: INDICATOR = 1: GOTO 7980
7970 FREEB = 1.5 + DD: INDICATOR = 0
7980 IF SS >= .4 THEN SS = .4: MESSAGE$ = "       CANAL SLOPE TO GREAT (ADJUSTED TO 0.
40) TRY SOMETHING LESS STEEP": GOSUB 8730
7990 IF SS <= .1 THEN GOSUB 8040 ELSE GOSUB 8730
8000 IF CTL > 0 THEN CTLSTR = INT((C3 * (40 + (11 + 3 * DD) * Q)) / 10) * 10
8010 CCANAL = INT(((EEX * AREACUT + REX * AREACUT + .166667 * (EEX + REX) * AREAFILL)
* CL + INDICATOR * (.3 * C3 + 9 * REX) * Q) / 10) * 10
8020 RETURN
8040 REM ************************  CANAL ON FLAT GROUND  **************************
8060 GUESS1 = 0                    'INITIAL ESTIMATE OF YO
8070 GUESS2 = 3                    'NEXT ESTIMATE OF YO
8080 COUNTER = 1                   'COUNTER
8090 GUESSO = GUESS1
8100 GOSUB 8250
```

```
8110 AREA1 = AREAQ
8120 COUNTER = COUNTER + 1
8130 GUESS0 = GUESS2
8140 GOSUB 8250
8150 AREA2 = AREAQ
8160 IF FLOWA + .001 > AREAQ AND AREAQ > FLOWA - .001 THEN 8230
8170 IF COUNTER = 100 THEN MESSAGE$ = "       The Parameters Provided for the CANAL Ga
ve no Solution": RETURN
8180 NEWY = (FLOWA - AREA1) / (AREA2 - AREA1) * (GUESS2 - GUESS1) + GUESS1
8190 GUESS1 = GUESS2
8200 GUESS2 = NEWY
8210 AREA1 = AREA2
8220 GOTO 8120
8230 IF GUESS0 > DOB THEN 8380 ELSE TYPE$ = "FLAT (EARTH ONLY)  ": RETURN
8250 REM ********************** SUBROUTINE ***************************************
8270 AREACUT = 5 * GUESS0 + 2 * GUESS0 ^ 2
8280 AREAFILL = .35 * AREACUT
8290 QUADU = 4
8300 QUADV = 12
8310 QUADW = -1.75 * GUESS0 - .7 * GUESS0 ^ 2
8320 QUADH = (-QUADV + SQR(QUADV ^ 2 - 4 * QUADU * QUADW)) / (2 * QUADU)
8330 AREAQ = 5 * (QUADH + GUESS0 - FREEB) + 2 * (QUADH + GUESS0 - FREEB) * ABS(QUADH +
 GUESS0 - FREEB)
8340 HEIGHTW = GUESS0 + QUADH - FREEB
8350 RETURN
8380 REM ******************  CANAL ON FLAT GROUND  (IN ROCK) ******************
8400 GUESS1 = 0: QUADH = 0
8410 GUESS2 = 3
8420 COUNTER = 1
8430 GUESS0 = GUESS1
8440 GOSUB 8600
8450 AREA1 = AREAQ
8460 COUNTER = COUNTER + 1
8470 GUESS0 = GUESS2
8480 GOSUB 8600
8490 AREA2 = AREAQ
8500 IF FLOWA + .001 > AREAQ AND AREAQ > FLOWA - .001 THEN TYPE$ = "FLAT (EARTH/ROCK)
 ": RETURN
8510 IF COUNTER = 100 THEN MESSAGE$ = "       The Parameters Provided for the CANAL Ga
ve no Solution": RETURN
8520 NEWY = (FLOWA - AREA1) / (AREA2 - AREA1) * (GUESS2 - GUESS1) + GUESS1
8530 GUESS1 = GUESS2
8540 GUESS2 = NEWY
8550 AREA1 = AREA2
8560 GOTO 8460
8580 REM ************************** SUBROUTINE ***********************************
8600 QUADU = 4
8610 QUADV = 12 - 2.8 * DOB
8620 QUADW = -(5.95 + .82 * GUESS0) * DOB - .35 * DOB ^ 2 - 1.09 * GUESS0 ^ 2
8630 QUADH = (-QUADV + SQR(QUADV ^ 2 - 4 * QUADU * QUADW)) / (2 * QUADU)
8640 AREAROCK = 2.17 * GUESS0 ^ 2
8650 AREACUT = (17 + 2.33 * GUESS0 + 8 * QUADH) * DOB + DOB ^ 2
8660 AREAFILL = .35 * AREACUT + .5 * AREAROCK
8680 HEIGHTW = GUESS0 + QUADH - FREEB
```

```
8690 IF HEIGHTW < GUESS0 THEN AREAQ = 2.17 * HEIGHTW * ABS(HEIGHTW): RETURN
8695 AREAQ = 2.17 * GUESS0 ^ 2 + (17 + 2.33 * GUESS0 + 8 * QUADH) * (QUADH - FREEB) +
2 * (QUADH - FREEB) ^ 2
8700 RETURN
8730 REM ***************  CANAL IN SLOPED GROUND  (NO ROCK)  ********************
8750 GUESS1 = 2                 'INITIAL ESTIMATE OF YO
8760 GUESS2 = 10                'NEXT ESTIMATE OF YO
8770 SLOPE = -SS                'MEAN TRANVERSE SLOPE
8780 COUNTER = 1                'COUNTER
8790 GUESS0 = GUESS1
8800 GOSUB 8940
8810 AREA1 = AREAQ
8820 COUNTER = COUNTER + 1
8830 GUESS0 = GUESS2
8840 GOSUB 8940
8850 AREA2 = AREAQ
8860 IF FLOWA + .001 > AREA2 AND AREA2 > FLOWA - .001 THEN TYPE$ = "SLOPED (EARTH ONLY
)": GOTO 9220
8870 IF COUNTER = 100 THEN MESSAGE$ = "       The Parameters Provided for the CANAL Ga
ve no Solution": RETURN
8880 NEWY = (FLOWA - AREA1) / (AREA2 - AREA1) * (GUESS2 - GUESS1) + GUESS1
8890 GUESS1 = GUESS2
8900 GUESS2 = NEWY
8910 AREA1 = AREA2
8920 GOTO 8820
8940 REM ************************** SUBROUTINE ************************************
8960 XPOINTA = -(GUESS0 / (.5 + SLOPE)): YPOINTA = (.5 * GUESS0) / (.5 + SLOPE)
8970 XPOINTB = GUESS0 / (.4 - SLOPE): YPOINTB = (.4 * GUESS0) / (.4 - SLOPE)
8980 AABO = .5 * ((YPOINTA + YPOINTB) * (XPOINTB - XPOINTA) - XPOINTB * YPOINTB + XPOI
NTA * YPOINTA)
8990 AMNO = 2.25 * (YPOINTB - 1) ^ 2
9000 AREACUT = AABO - AMNO
9010 AREAFILL = .5 * AREACUT
9020 POINTA = YPOINTB + .89
9030 POINTB = 2.5
9040 POINTC = 2.5 * YPOINTB + 2.22
9050 POINTD = 2.25 / (.5 + SLOPE)
9060 POINTE = (2.25 * YPOINTB + 2 - GUESS0) / (.5 + SLOPE)
9070 POINTF = 2.25 * SLOPE / (.5 + SLOPE)
9080 POINTG = (2.25 * SLOPE * YPOINTB + 2 * SLOPE + .5 * GUESS0) / (.5 + SLOPE)
9090 QUADU = POINTD - POINTB * POINTF
9100 QUADV = YPOINTB * (POINTB - POINTD) + XPOINTB * (POINTF - 1) + POINTA * POINTD -
POINTB * POINTG - POINTC * POINTF + POINTE
9110 QUADW = YPOINTB * (POINTC - POINTE) + XPOINTB * (POINTG - POINTA) + POINTA * POIN
TE - POINTC * POINTG - 3.56 - AREACUT
9120 QUADH = (-QUADV + SQR(QUADV ^ 2 - 4 * QUADU * QUADW)) / (2 * QUADU)
9130 AB = 2 * (QUADH + 1)
9140 BOTTOMW = 4.5 * (YPOINTB - 1) - 2
9150 TOPW = 4.5 * (QUADH + YPOINTB) - 2
9160 HEIGHTW = QUADH + 1 - FREEB
9170 AREAQ = ABS(BOTTOMW) * HEIGHTW + 2.25 * ABS(HEIGHTW) * (HEIGHTW)
9180 RETURN
9200 REM ******************* THIS A CHECK TO SEE IF ROCK LINE ********************
9210 REM ******************* APPEARS IN AN EARTH ONLY SECTION ********************
```

```
9220 MM = GUESS0 - (YPOINTB - 1) * (1 + SLOPE * 2)
9230 IF MM > DOB THEN 9260 ELSE RETURN
9260 REM ***************  CANAL IN SLOPED GROUND  WITH ROCK  ********************
9280 GUESS1 = 0                  'INITIAL ESTIMATE OF YO
9290 GUESS2 = 5                  'NEXT ESTIMATE OF YO
9300 COUNTER = 1                 'COUNTER
9310 GUESS0 = GUESS1
9320 GOSUB 9470
9330 IF AREAQ >= FLOWA THEN TYPE$ = "SLOPED (EARTH/ROCK)": RETURN
9340 AREA1 = AREAQ
9350 COUNTER = COUNTER + 1
9360 GUESS0 = GUESS2
9370 GOSUB 9470
9380 AREA2 = AREAQ
9390 IF FLOWA + .001 > AREAQ AND AREAQ > FLOWA - .001 THEN TYPE$ = "SLOPED (EARTH/ROCK
)": RETURN
9400 IF COUNTER = 100 THEN MESSAGE$ = "       The Parameters Provided for the CANAL Ga
ve no Solution": RETURN
9410 NEWY = (FLOWA - AREA1) / (AREA2 - AREA1) * (GUESS2 - GUESS1) + GUESS1
9420 GUESS1 = GUESS2
9430 GUESS2 = NEWY
9440 AREA1 = AREA2
9450 GOTO 9350
9470 REM ************************** SUBROUTINE **********************************
9490 DELTA = DOB / (ABS(SLOPE) + .4) * .4 - 1.5 * ABS(SLOPE)
9500 GUESSY = (-(4 + .3333333 * GUESS0) * SLOPE) / (1 + .1666667 * SLOPE)
9510 HTWO = GUESS0 + GUESSY
9520 HONE = GUESS0
9530 WTHREE = 7 + .1666667 * (HONE + HTWO)
9540 WTWO = 4 + .33333 * GUESS0
9550 AREAROCK = 4 * GUESS0 + .16667 * GUESS0 ^ 2 + WTWO * GUESSY * .5
9560 AREACUT = WTHREE * DOB + 2.25 * DOB ^ 2
9570 AREAFILL = .5 * (AREACUT + AREAROCK)
9580 QUADU = 4.5 + 11.25 * ABS(SLOPE)
9590 QUADV = 12 + 30 * ABS(SLOPE)
9600 QUADW = (36 + 4 * AREAFILL) * ABS(SLOPE) - 2 * AREAFILL
9610 QUADH = (-QUADV + SQR(QUADV ^ 2 - 4 * QUADU * QUADW)) / (2 * QUADU)
9620 IF QUADH < 0 THEN 9640
9630 GOTO 9680
9640 IF DELTA >= 0 THEN HEIGHTW = HONE + DELTA - FREEB ELSE HEIGHTW = HONE - FREEB
9650 AREAFILL = 18 * ABS(SLOPE) / (1 - 2 * ABS(SLOPE))
9660 IF AREAFILL > AREACUT + AREAROCK THEN AREAFILL = AREACUT + AREAROCK
9670 GOTO 9690
9680 HEIGHTW = HONE + DELTA + QUADH - FREEB
9690 IF HEIGHTW <= HONE THEN AREAQ = 4 * HEIGHTW + .16667 * HEIGHTW ^ 2: RETURN
9700 IF HEIGHTW > HONE AND HONE <= HTWO THEN BWTWO = 4 + .33333 * HONE + 1.5: GOTO 972
0
9710 GOTO 9730
9720 AREAQ = 4 * HONE + .16667 * HONE ^ 2 + BWTWO * (HEIGHTW - HONE) + 1.3333 * (HEIGH
TW - HONE) ^ 2: RETURN
9730 IF HEIGHTW > HTWO THEN BWTHREE = 7 + 2.66667 * HTWO - 2.33333 * HONE
9740 AREAQ = 4 * HONE + .16667 * HONE ^ 2 + BWTWO * (HTWO - HONE) + 1.3333 * (HTWO - H
ONE) ^ 2 + BWTHREE * (HEIGHTW - HTWO) + 2 * (HEIGHTW - HTWO) ^ 2
9750 RETURN
```

```
9800 REM ********************** 1991 UPDATE ************************************
9825 RMF = 4.5
9827 FREQ = 60
9830 KW = M * 1000
9840 NETH = H * .94
9850 QT = .116 * KW / NETH / U
9860 IF H <= 8 THEN BLADES = 4: DTF = .01: GOTO 9920
9870 IF H > 8 AND H <= 16 THEN BLADES = 6: DTF = .01: GOTO 9920
9880 IF H > 16 AND H <= 100 THEN BLADES = 13: DTF = .02: GOTO 9920
9890 IF H > 100 AND H <= 200 THEN BLADES = 15: DTF = .02: GOTO 9920
9900 IF H > 200 AND H <= 300 THEN BLADES = 17: DTF = .02: GOTO 9920
9910 IF H > 300 THEN BLADES = 19: DTF = .02
9920 BARP = 10.2 - .002 * TWE ^ .92
9930 RTV = (1.49 * BLADES ^ .28) * (TSUB + BARP + RMF - 5 - 2.3 * Q3) ^ .5
9940 TTD = 1.128 * (QT / RTV) ^ .5
9950 IF NETH > 16 AND TTD > 1.8 THEN SHAFT$ = " (Vertical Shaft)" ELSE SHAFT$ = " (Hor
izontal Shaft)"
9960 RSPEED = (1000 * (NETH - DTF * RTV ^ 2) ^ .32) / ((TTD ^ .9) * (RTV ^ .45) * (BLA
DES ^ .36))
9970 IF KW < 1000 AND RSPEED < 200 THEN 9980
9975 GOTO 10000
9980 REM ***************** Gearbox Subroutine ************************************
9985 IF KW < 500 AND RSPEED > 100 THEN GSPEED = 900 ELSE GSPEED = 600
9990 POLES = 120 * FREQ / GSPEED
9995 GOTO 10050
10000 REM ***************** No Gearbox Subroutine *********************************
10010 POLES = CINT((120 * FREQ / RSPEED) / 4) * 4
10020 IF POLES < 4 THEN POLES = 4
10030 GSPEED = 120 * FREQ / POLES
10040 RSPEED = GSPEED
10050 MVA = KW / 1000 / .9
10060 RWEIGHT = (50 * (MVA) ^ .74) / GSPEED ^ .37
10070 RETURN
10100 REM ******************** Print Results ************************************
10101 LPRINT TAB(26); "SHYDRO-PC VERSION 3.2   MARCH  1991": LPRINT : LPRINT
10102 LPRINT TAB(30); "   EQUIPMENT DATA SHEET   ": LPRINT
10103 LPRINT TAB(32); "   DATE : "; DATE$: LPRINT : LPRINT : LPRINT
10104 LPRINT "       WATER SHED : "; W$
10105 LPRINT "       ------------"
10106 LPRINT "       SITE NAME : "; S$
10107 LPRINT "       -----------"
10108 LPRINT "       FILE : "; F$
10109 LPRINT "       ------": LPRINT
10110 LPRINT USING "       INSTALLED CAPACITY :  ##,###,###" + " kW"; M * 1000
10115 LPRINT "       --------------------": LPRINT
10120 LPRINT
10125 LPRINT USING "       AVERAGE YEARLY ENERGY :##,###,##" + " GWh"; Q1 * C(28) * H
* 8.1428900000000001D-06 * 8766
10130 LPRINT "       ----------------------": LPRINT
10135 LPRINT : LPRINT
10140 LPRINT "       POWERHOUSE EQUIPMENT DATA"
10145 LPRINT "       -------------------------": LPRINT
10147 LPRINT "             PENSTOCK " + P$
10150 LPRINT USING "                   Penstock Diameter                    #
```

```
##.##" + " m"; P1
10155 LPRINT USING "                    Penstock Thickness                    ##
#####" + " mm"; P2: LPRINT
10157 LPRINT "                  TURBINE" + SHAFT$
10160 LPRINT USING "                    Number of Runner Blades per Unit
  ###"; BLADES
10165 LPRINT USING "                    Runner Throat Velocity                ##
##.##" + " m/s"; RTV
10170 LPRINT USING "                    Runner Speed                          ##
###.#" + " rpm"; RSPEED
10175 LPRINT USING "                    Turbine Flow per Unit                 ##
##.##" + " m^3/s"; QT
10180 LPRINT USING "                    Turbine Throat Diameter               #
##.##" + " m"; TTD
10185 LPRINT USING "                    Turbine Submergence                   ##
#.###" + " m"; TSUB: LPRINT
10187 LPRINT "                  GENERATOR"
10190 LPRINT USING "                    Generator Speed                       ##
###.#" + " rpm"; GSPEED
10195 LPRINT USING "                    Number of Generator Poles per Unit    ##
#####"; POLES
10200 LPRINT USING "                    Rotor Weight per Unit                 ##
#####" + " Tonnes"; RWEIGHT
10210 LPRINT CHR$(12)
10230 RETURN
```